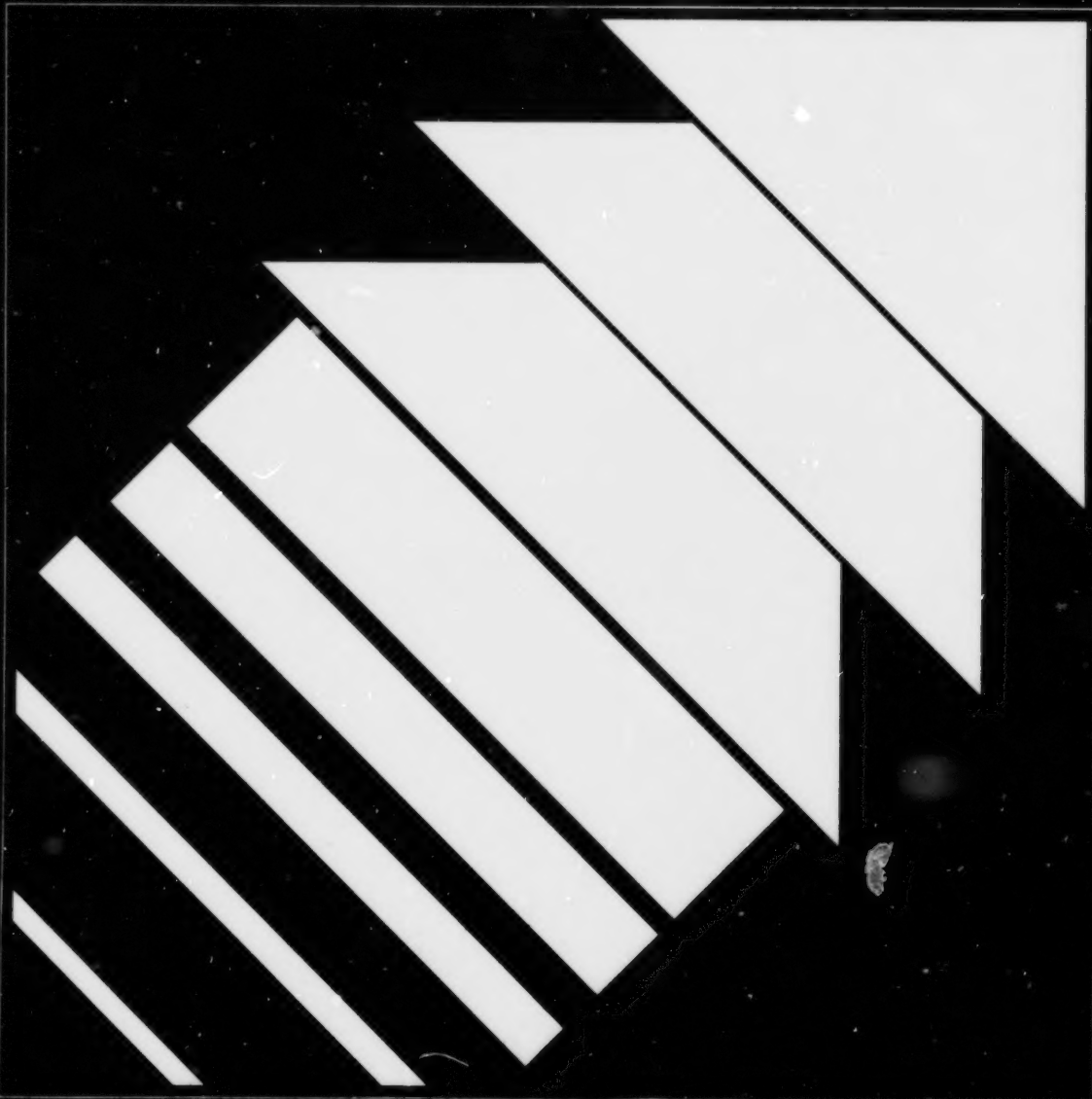


NATIONAL  
URANIUM  
TAILINGS  
PROGRAM



Energy, Mines and  
Technical Services  
Ministère de l'énergie,  
des mines et des  
services techniques

Canada

A Study of Naturally Occurring,  
Radionuclide Bearing Deposits  
at Portland Creek, Newfoundland

(DSS File No. 26SQ.23241-4-1676  
Contract No. OSQ84-00074)

Study Carried Out For:

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MAR 3 1988

ABSTRACT

A small uraniferous peat deposit located near Portland Creek, Newfoundland was investigated as part of the National Uranium Tailings Program (NUTP). The purpose of the investigation was to provide data on naturally occurring uranium series radionuclides at a surface location that could be used to compare with the predictions of mathematical models.

The investigation was carried out between August 18 and 30, 1984 by CBCL Limited with the assistance of Golder Associates, SENES Consultants Limited, Environmental Design Group and Monenco Analytical Laboratories. The investigation involved the determination of the geological and hydrogeological conditions of the deposit site and the collection of soil, water and biological samples. The samples were analyzed for major element chemistry, uranium and its various decay series radionuclides including radium-226 and the ratio of uranium-234 to uranium-238.

The uranium mineralization was found to be associated with a peat deposit that has accumulated in post-glacial time. The deposit is situated within a groundwater discharge zone at the toe of a granitic talus pile that extends downward from the Long Range Mountains. The concentration of uranium within the peat deposit was found to vary from 100 to 28000 ppm, however, the activities of the uranium decay series radionuclides were comparatively very low. Radium-226 activities were found to vary from 0.5 Bq/g to 15.0 Bq/g. Little influence from the deposit was noted in the surrounding water bodies, fish samples and vegetation.

Based on the results of the study the uranium mineralization within the peat is considered to be the result of precipitation or adsorption from groundwater that had previously leached uranium from the granitic talus which forms the groundwater recharge zone. The major geochemical mechanism for deposition is considered to be associated with the strong reducing conditions encountered within the peat. Being a recent deposit (i.e. less than 10,000-15,000 years old) little time has been available for the ingrowth of radionuclide daughter products of uranium. The deposition of uranium within the peat deposit is considered to be an ongoing process.

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## 1.0 INTRODUCTION

### 1.1 Overview

In 1982, the National Uranium Tailings Program (NUTP) was formed by the Department of Energy, Mines and Resources. The main objective of this 5-year program is to provide a scientifically credible information base which will assist government regulatory agencies in establishing criteria for the long-term protection of man and his environment.

To achieve this objective, the program has been divided into three components: modelling, measurement and disposal technology. In developing the program structure, the strategy has been to use modelling to provide a sense of direction for the entire program. Although central to the program, modelling requires measurement inputs to calibrate and validate models, and disposal technology inputs to evaluate the consequences of different disposal options and to relate their performance to cost. The main component, modelling, will provide a tool to predict long-term behaviour and dispersion of uranium tailings constituents within and beyond a tailings management area.

One of the objectives of the measurement component was to study radionuclide concentrations and movements in the area of a naturally occurring radionuclide deposit and obtain data which could subsequently be used to validate the NUTP models. The Scientific Authority reviewed several potential study sites and eventually selected a natural uranium deposit located about 15 kilometres (km) east of the communities of Portland Creek and Daniels Harbour on the west coast of Newfoundland (see Figure 1 for location). This deposit was



thought to be similar to some uranium tailings areas found in Saskatchewan and Ontario, i.e. it experiences a similar climate, the watertable is near the surface, and it is underlain by glacial till and bedrock. Further, the type of forest vegetation found at the deposit was similar to that which might be expected to eventually cover tailings areas.

In June 1984, CBCL Limited was selected to collect environmental samples from the deposit and the surrounding area and provide a factual report on the findings of the investigation with a limited interpretation of the data. The study was divided into three phases:

Phase 1 - This phase involved an initial site reconnaissance visit, review of available background information, and development of a study plan for the succeeding phases.

Phase 2 - This phase included the actual field sampling program and the subsequent laboratory analyses.

Phase 3 - This phase involved the preparation of the report for the study and limited interpretation of the data.

This report focusses on Phases 2 and 3, although some Phase 1 activities are noted in Section 2.1. A separate Phase 1 report was submitted to NUTP in August 1984 (CBCL, 1984).

## 1.2 Study Team

The multi-discipline study team, headed by CBCL Limited, comprised specialists from Golder Associates, SENES Consultants Limited, Environmental Design Group, and Monenco Analytical Laboratories. Each team member was responsible for various project tasks:

CBCL Limited - provided overall project management, client liaison, field team mobilization and logistical support, surface water hydrology, topographic surveying and mapping, report assembly and production.

Golder Associates - planned and implemented the geological, hydrogeological and geochemical aspects of the field testing and sampling program, and together with SENES, analysed and documented the study results.

SENES Consultants Limited - planned and implemented the radiological, chemical and microbiological aspects of the field program; co-ordinated sampling activities; planned the analytical laboratory testing program, and participated with Golder Associates in the analysis and documentation of study results.

Environmental Design Group - planned and implemented of the aquatic and terrestrial biology aspect of the field program and provided input for the biological aspects of the analytical laboratory testing program.

Monenco Analytical Laboratories - provided the radiological and chemical laboratory services.

Overall project management was handled by C.R. Elliot of CBCL Limited with assistance from J.E. Davis of Golder and D.M. Gorber of SENES. The Golder Associates offices in St. John's carried out the requisite geotechnical laboratory testing, while mineralogical analysis was carried out by Memorial University of Newfoundland. The analysis of radon-222 concentration in ground water was performed at the Division of Clinical Chemistry, Victoria General Hospital in Halifax, Nova Scotia. Micro-biological analyses (microorganisms in peat) were carried out by Professor Charles at the University of Waterloo.

## 2.0 DESCRIPTION OF THE 1984 FIELD PROGRAM

### 2.1 Reconnaissance Survey

On July 16, 1984 representatives of the Scientific Authority, the provincial Department of Mines and Energy, CBCL Limited, and Golder Associates made a one day reconnaissance trip to the study site. The purpose of the visit was to verify site conditions, assess accessibility for personnel and equipment and locate a suitable camp site.

The reconnaissance visit provided an excellent opportunity to review the logistical difficulties the field program would encounter. It was evident from the ruggedness and remoteness of the study area that the drillrig required during the field program would have to be mobilized by air. A previously used campsite near the southern end of Suitcase Lake was selected for the camp.

On July 17, 1984 key project personnel and other interested participants in the study met with the scientific officer in St. John's. The purpose of this meeting was to review the Terms of Reference and to generally ensure a clear understanding of the study plan. The results of the reconnaissance

visit and the meeting were included in a report dated August 7, 1984 which was submitted to the Scientific Authority for approval before commencing with Phase 2 of the study.

The field program began after approval of the study plan for Phase 2. Each team member made appropriate plans for their activities with CBCL co-ordinating shipping and preparation requirements. Actual mobilization from Daniels Harbour to the site occurred on August 18, 1984.

## 2.2 Logistics

### 2.2.1 Field Camp

On August 18 (Day 1 of the field program), a camp was established on the southeastern shore of Suitcase Lake at the site previously used by mineral exploration crews (see Figure 2 for location). An existing trail approximately 1.5 km long runs between the camp and the deposit. A helicopter was used to ferry equipment and supplies from Daniels Harbour to the camp. Most field crew members reached the camp via a trail from the eastern shore of Portland Creek Pond.

Appropriate safety measures were taken during the field investigations. A battery operated radio-telephone was installed and used throughout the field program. First aid kits and fire extinguishers were kept at both the camp and the deposit. A boat was ready at all times at the end of the trail on Portland Creek.

During the field programs environmental samples were stored in insulated containers at the site prior to shipment. On Days 5, 10 and 12, various samples were transported by helicopter to the nearest commercial airport at Deer Lake, approximately 90 km south of the site.

On August 30 (Day 13), the camp was demobilized and all equipment and personnel transported to the community of Portland Creek.

#### 2.2.2 Field Personnel and Responsibilities

During the field program, various study team members were on site throughout the study period, Mr. J. Moffatt of CBCL Limited gathered data pertaining to surface water hydrology, and weather and carried out topographic surveys of the deposit. He also supervised logistical support related to the camp operations and the transfer of field personnel into and out of camp.

Other field personnel included Dr. B. Roberts of the Environmental Design Group who collected biological samples, Mr. R. Blair of Golder Associates who supervised the geotechnical aspects of the field program, and Mr. B. Ibbotson of SENES Consultants who conducted the surface water and sediment sampling program and took radioactivity measurements.

Two drillers and a diamond drill rig from Longyear Canada Inc and an engineering technician from Golder Associates were on-site from Day 5 to Day 10 to put down boreholes. A cook and two labourers employed for line cutting and test pit digging, were on-site throughout the field program.

#### 2.2.3 Survey Control

One of the first tasks of the field program was to establish a survey grid over the deposit and the immediately surrounding study area. This grid was subsequently used to establish accurate sample locations for the other components of the field program.



A picket line grid previously established by Conwest Exploration Ltd. proved suitable for horizontal control. Within the study area the grid included two north-south baselines (9+00 E and 10+00 E) and three east-west crosslines (20+00 N, 24+00 N and 28+00 N). Portions of these lines were re-cut and chained and two new lines were added (22+00 N and 26+00 N). The survey grid is shown on Figure 3.

The Imperial chainage system used for the existing grid, including line numbers, and picket stations (25 ft or 7.5 m) were re-established to provide continuity between the previous mineral exploration work and this investigation.

Line 24+00 N was selected as the main axis of the investigation based on the results of the site reconnaissance carried out on Day 1. This line was re-cut to a width of 1.5 m between Stations 6+00E and 10+50E to provide an access route for the diamond drill. A 25 m wide helicopter pad was cleared at the intersection of Lines 24+00N and 10+00E to establish the first drill site (see Figure 3).

Vertical control including ground surface, borehole and piezometer elevations was established using a levelling transit. The approximate elevation of the site was determined based on an interpretation of the position of the 450 ft. contour located between Middle Pond and Falls Lake as shown on the 1:50,000 scale National Topographic Map of the area (see Figure 2). From this position, the approximate elevation of a boulder in Falls Lake was surveyed and subsequently used as the site benchmark which, while close to Geodetic datum, must be taken as Local datum.

The vertical control is reported in metres and the elevation contours determined for the site are shown on Figure 3.



### 2.3 Radiation Survey

During the field program, gamma radiation levels were measured over the deposit and in the surrounding area. Measurements were taken using two scintillometers: a SRAT SPP-2 which produces readings in units of counts per second (cps); and Eberline PRM-7 which produces readings in units of micro rem per hour (uR/hr).\*

Initially the SPP-2 was used in a preliminary investigation of the deposit. Readings were taken at ground level at approximately 5 m (15 ft) intervals along the old exploration grid lines. Once the lines had been re-surveyed and distances accurately marked along the lines, gamma levels were measured at 7.5 m intervals using the PRM-7. The first survey allowed comparisons to be made with the previous results of the exploration efforts, while the second better characterized the site.

Gamma radiation measurements were also taken at various depths in the test pits, at the field camp on Suitcase Lake, along the trail between the camp and the site, along the eastern and southern shore of Falls Lake, around several springs, and at other areas of interest.

### 2.4 Subsurface Investigation

The subsurface investigation included geological mapping, hand auger probes, test pits, boreholes and piezometer installations. In addition, soil samples and water samples were collected for analyses.

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\* The SI unit for exposure is coulomb/kilogram where  $1 \text{ R} = 258 \text{ uC/kg}$ . However, for gamma radiation,  $1 \text{ R} = 1 \text{ rem} = 0.01 \text{ Sv}$ . Therefore  $1 \text{ uR/hr} = 0.01 \text{ uSv/hr}$ . For convenience throughout this report field measurements are given in uR/hr, the units of the scintillometer.

#### 2.4.1 Hand Auger Probes

Hand auger probing was carried out at 7.5 m intervals along the survey grid to delineate the extent and thickness of the peat deposit. Maximum thicknesses of 1.75 m were encountered. Where possible, samples of the soil underlying the peat were collected for chemical analyses. These sample locations are shown on Figure 4. The augering was carried out in conjunction with the geological mapping and radiometric surveys between August 20 and 23, 1984.

#### 2.4.2 Test Pits

Ten test pits were hand dug in the peat deposit between August 24 and 27 (see Figure 4). The pits varied in depth from 0.60 m to 1.5 m. The depths were limited by the presence of water flooding into the pit or difficulty in digging further due to very dense soil. The stratigraphy encountered in each pit was recorded and the levels of radioactivity in six of the pits were logged with depth. Sampling of the peat and underlying gravels was carried out at depth intervals of 0.10 m to 0.25 m depending on pit conditions. The elevations of the test pits were surveyed on completion. Detailed logs of each test pit and grain size distributions for selected soil samples are included in Appendix A.

#### 2.4.3 Boreholes

Boreholes were put down at four locations on Line 24+00N as shown on Figure 4. At each location, one borehole was continuously sampled through the overburden using a 35 mm I.D. split barrel sampler. These boreholes were advanced through the overburden using wash boring techniques (BW size

casing) and were advanced into the bedrock by coring in BW size for depths of about 3 m, 1.1 m and 0.5 m (borehole locations 1, 2 and 3 respectively). Bedrock was not encountered in BH-4. The total depths of the continuously sampled boreholes varied from 3.18 m to 7.75 m. In addition to the four continuously sampled boreholes, three unsampled BW size boreholes were put down in the overburden, two at borehole location 1 and one at borehole location 2 to installing nested piezometers.

The drilling was carried out by Longyear Canada Inc. using a small Longyear Model 24 diamond drillrig which was mobilized to site by helicopter. The boreholes were located in the field by the project hydrogeologist. The drilling and sampling was supervised throughout by Golder Associates' engineering technician who logged the borings and prepared the samples for shipment to Golder Associates' soils laboratory in St. John's for detailed examination and geotechnical testing. Following logging, the rock core was left on site in wooden core trays.

The results of the drilling and testing are shown on the Record of Borehole sheets in Appendix A. Grain size distributions for selected soil samples are also included in Appendix A .

#### 2.4.4 Piezometer Installations

Piezometers were installed in each of the seven boreholes immediately following drilling. A nest of three piezometers, consisting of one in bedrock and two in the overburden, was installed at borehole location 1. A nest of two piezometers

was established at borehole location 2, one in bedrock and the other in the peat deposit. A single piezometer was installed in the overburden at each of borehole locations 3 and 4. An additional four piezometers were installed in test pits No. 1, 2, 6 and 9. The elevation of the top of the piezometer riser pipe was surveyed to provide a datum for groundwater level measurements. Details of the piezometer installations are shown on the Record of Boreholes and Test Pits in Appendix A.

The piezometers were constructed of 32 mm diameter PVC pipe with a 0.9 m long porous polyethylene (vyon) piezometer screen. The borehole piezometers were installed through the casing which was then withdrawn, allowing the overburden to cave around the pipe. Bentonite seals were placed near the surface of each borehole installation to prevent entry of surface water.

The piezometers installed in the boreholes were bailed to remove drilling water. In piezometers P1-1 and P1-2 at borehole location 1, and P2-1 at borehole location 2, clear water with an electrical conductivity considered to be representative of the formation groundwater (compared to that of the drillwater) was obtained. However, despite attempts to develop the wells the groundwater obtained from piezometers P1-3, P2-2, P3-1 and P4-1 remained turbid due to suspended silt and organic material that penetrated the screen.

The piezometers installed in the test pits were backfilled with the organic material from the pits because of the large size of the excavations. Consequently, the water obtained was very turbid.

#### 2.4.5 Soil Sampling

A total of 26 borehole soil samples, 50 test pit samples and 13 auger probe samples were collected by the engineering technician and hydrogeologist between August 21, and 29. All samples were packaged in sealed plastic bags and appropriately labelled in the field prior to shipment to the Golder Associates' soils laboratory in St. John's, Newfoundland.

Bulk samples of approximately 1 to 4 kg were collected from the test pits including both peat and the underlying mineral soils. Due to the accessibility of the pit, they were channel sampled in intervals across the full height of the pit wall. This provided a high degree of sampling control such that discrete samples from individual soil layers could be collected with a minimum of sample contamination from adjacent layers. Smaller soil samples of 0.1 to 1 kg were obtained from the boreholes due to the limited size of the sampler and the amount of sample recovered.

The auger probe samples were small, approximately 0.1 to 0.25 kg due to the limited sampling ability of the tool. All of these samples were collected from the mineral soils that directly underlie the peat deposits. However, they were extensively contaminated with organic peat when the probe passed through the peat deposit.

The soil samples were prepared in the Golder Associates' laboratory prior to chemical analyses. This included drying and grain size classification to separate individual mineral soil samples into silt, sand and gravel sizes such that each size fraction could be chemically analyzed. The peat samples were dried prior to chemical analyses. The results of the chemical analyses are presented in Tables B3 and B4 in Appendix B.



#### 2.4.6 Groundwater Sampling

A total of 11 groundwater samples were collected between August 27 and 29 for chemical analyses. These included samples from the 7 borehole piezometers, seepage water collected in Test Pits 1 and 5, and groundwater from springs located at Test Pit 10 and at the intersection of Lines 28+00N and 12+00E.

The water samples were collected in 4 L polyethylene bottles. Sample preparation was carried out on five of the samples. This included field filtration through a 0.45 micron filter and acidification of filtered samples intended for cation and radionuclide analyses using nitric acid. However, the samples from the test pits and shallow piezometers (TP-1, TP-5, P1-3, P2-2, P3-1 and P4-1) could not be filtered due to suspended organic matter from the peat. These samples were shipped as collected and filtration and acidification was carried out by the laboratory. The samples were placed in shipping crates for direct delivery by air express to the Monenco Laboratories in Calgary, Alberta to minimize the delay time between sampling and receipt by the laboratory. The results of the analysis are presented in Table B-5 in Appendix B.

#### 2.4.7 Radon in Groundwater

On August 29, samples for radon-222 analysis were taken from several piezometers, test pits at the deposit that had filled with ground water, two springs at the deposit, a creek that flowed across the deposit, and Brucy Brook. Two samples were taken at each location. To minimize the possible loss of radon to the atmosphere during sample collection, a syringe



was used to inject the water samples into vials containing a scintillation liquid which was subsequently counted in a liquid scintillation counter (for example, see Prichard and Gesell, 1977). Care was taken to accurately record the time of collection and promptly ship the samples to the laboratory.

## 2.5 Surface Water and Sediment Sampling

### 2.5.1 Surface Water Samples

Between August 22 and 29, 1984, surface water samples were collected from ten stations. The locations (shown on Figure 5) included both branches of Brucy Brook, the inlet and outlet of Falls Lake, two creeks and a spring in the immediate vicinity of the peat deposit, and the outlet of Suitcase Lake.

Each station was sampled on two occasions, usually several days apart. On each occasion, the samples taken included a 4 L sample (acidified with nitric acid), a 1 L sample (also acidified), and a second 1 L sample to which no preservatives were added. Field measurement were made of pH and temperature. The samples were not filtered prior to acidification. The samples were sent to the Monenco laboratory for analyses. The analytical results are listed on Tables C-3 and C-4 in Appendix C.

### 2.5.2 Sediment Samples

Between August 22 and 29, 1984, sediment samples were collected at the ten surface water stations noted in Section 2.5.1 and at another ten stations in the study area. The sampling

locations (shown on Figure 5) included both branches of Brucy Brook, eight locations on Falls Lake, two creeks and a spring in the immediate vicinity of the deposit, and the outlet of Suitcase Lake.

Each station was sampled once. The samples were collected in 1 L plastic containers. Where sediment was shallow, several scoops were taken at the site to make up the sample. The samples were representative of the upper 2 to 5 cm of sediment. Samples were collected from water depths of up to one metre. The results of the analyses are presented on Table C-4 in Appendix C.

## 2.6 Biological Surveys

### 2.6.1 Vegetation

The vegetation component of the field program included the preparation of a species inventory and the collection of samples for analysis of uranium content and several radionuclides. Vegetation samples were collected from two locations within the peat deposit. A third site at the southern end of Suitcase Lake was selected as the control sampling area (for location see Figure 6). The control site is beyond the influence of the deposit and located in a drainage basin adjacent to the one that contains the deposit.

To determine the uranium content of parts of a common plant species, three random composite samples were taken of the foliage, bark, wood and roots of balsam fir. It is relatively easy to determine the age of balsam fir foliage as each year that it grows, the terminal bud forms a whorl of branches. Each branch consistently divides into three shoots each

year, so the age of a branch can be determined by counting back the shoots on the branch. This method works for about six to seven years. Accordingly, the foliage samples of balsam fir included those from 1984 and 1980.

Three composite samples were also collected of 1984 foliage from black spruce, white birch, bunchberry, wood fern, two lichen species and feather moss from both the control and peat deposit sampling sites. Three other species found in the study area but not at either sampling site, were also collected.

The results of the analyses of the vegetation samples are given in Tables D-1 and D-3, Appendix D.

#### 2.6.2 Aquatic Invertebrates

Insect larvae and other invertebrates were collected from two locations in the study area as shown on Figure 6. Of these, the stream at the outlet of Falls Lake was used as the sampling location to study possible effects downstream from the peat deposit. The control sampling site was the stream that flows into the southern end of Suitcase Lake.

Specimens were collected using standard Surber drift sampling techniques. At each site, two one-hour samples and one eight-hour sample were collected. The large amount of stream debris (twigs, leaves, mud, etc.) made it impossible to obtain 24-hour samples of downstream drift.

Based on the low number of invertebrates observed during the previous project reconnaissance trip to the area and after consultation with the Scientific Authority, it was decided

that the scarcity of invertebrates would make it impractical to gather enough for chemical analysis. The samples that were collected were preserved and sent to a laboratory for species identification. The results are shown in Appendix D.

### 2.6.3 Fish

Due to the relatively low numbers of invertebrates observed in the study area (see above), it was decided to collect fish for analyses of radionuclide activity. The specimens were collected at the Falls Lake outlet site and the control site located at the south end of Suitcase Lake (see Figure 6). Several dozen Eastern Brook Trout were caught using a fly rod. The fish were described in terms of physical characteristics such as length, girth and fresh weight (see Table 19).

A separate composite sample of stomach contents and of flesh and bone obtained from six fish specimens were made for each of the sampling sites. The fish specimens used were in the size range of 10 to 20 cm long. The four composite samples produced were then analyzed for the total uranium and the U-238 decay daughters. The results are listed on Table D2 in Appendix D.

### 2.6.4 Microorganisms in Peat

In an effort to identify the predominant types and relative abundance of microorganisms present in the peat deposit, peat samples were collected from Test Pits 5, 8 and 10 (see Figure 4 for locations). The pits were selected because they included areas with anomalous gamma radiation (50  $\mu\text{R/hr}$ ) and they were well situated within the main mineralized portion of the peat deposit. Test Pits 5 and 8 were situated in a downstream location and Test Pit 10 was situated in an upstream location at the springline of the talus pile.

Samples from Test Pit 5 were taken from depths of 0.1 m and 0.6 m. Samples from Test Pit 8 were taken from 0.15 m and 0.5 m. These samples were representative of peat from above and below the watertable in each pit. Samples from Test Pit 10 were collected from depths of 0.2 m and 1.0 m, both being below the watertable as this test pit was located at a spring. Immediately following collection, the samples were shipped to the University of Waterloo for analysis.

Once in the laboratory, a 50 g sample of each peat sample was placed in 500 mL of sterile saline solution. The suspension was shaken vigorously for at least 5 minutes, and the coarse particles allowed to settle. One millilitre of the supernatant fluid was added to 99 mL of sterile saline solution and further 10-fold dilutions carried out to a maximum of  $10^{-6}$ .

From each of the  $10^{-4}$ ,  $10^{-5}$ , and  $10^{-6}$  dilutions, 0.5 mL aliquots were plated on each of four media. Trypticase soy agar (TSA) was used to determine the presence of heterotrophic bacteria, Sabouraud dextrose agar (SDA) was used to isolate fungi, Thiobacillus medium containing 0.5 per cent thiosulphate (TM) was used to isolate sulfur-oxidizing bacteria, and Silverman's 9K medium (SM) was used to study iron-oxidizing bacteria.

Triplicate sets of plates were incubated aerobically and anaerobically at 30°C, and were read after incubation periods of 3 and 7 days. Total counts were calculated from those containing between 30 and 400 colonies to ensure reliability in the values obtained. Results were expressed as the average counts of the three plates.



## 2.7 Schedule of Chemical Analyses

Chemical analyses of the various soil, water and biology samples collected during the field investigations were carried out in five stages by Monenco Laboratories. The sixth stage, measurement of Radon-222 in water was carried out by the Division of Clinical Chemistry, Victoria General Hospital in Halifax, Nova Scotia. Based on a review of the analytical results of the previous stage, decisions were made by Golder and SENES as to which samples would be analyzed in the next stage. The type and number of the samples analysed for each stage of the program and the analytical parameters included in each stage are shown on Table 1.

Detailed schedules of analyses for the individual soil, and groundwater samples are provided on Table B-1 and B-2 in Appendix B. The schedules for surface water and stream sediment samples collected during the investigation are provided on Tables C-1 and C-2 in Appendix C.

## 3.0 REGIONAL PHYSIOGRAPHY, GEOLOGY, METEOROLOGY, AND HYDROLOGY

### 3.1 Physiography and Geology

The site is situated on the edge of the Western Coastal Plain of Newfoundland at the foot of the Long Range Mountains (see Figure 7). The coastal plain is some 12 to 15 km wide and gently rises from the Gulf of St. Lawrence to between elevations 140 and 150 m within the study area (i.e at the base of the mountains). As indicated on Figure 7, the coastal plain is underlain by Cambrian and Ordovician limestone strata that vary from flat-lying to gently dipping.



TABLE 1

SCHEDULE OF CHEMICAL ANALYSESStage of Analysis and Number of Samples Analyzed in Each

| <u>Sample Type</u> | <u>Stage 1</u> | <u>Stage 2</u> | <u>Stage 3</u> | <u>Stage 4</u> | <u>Stage 5</u> | <u>Stage 6</u> |
|--------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Surface Water      | 20             | 10             | 8              | 5              | 3              | 3              |
| Ground Water       | 11             | 11             | 11             | 4              | 4              | 9              |
| Stream Sediment    | 20             | 10             | 10             | 6              | 3              | -              |
| Soil               | 106            | 20             | 10             | 4              | 3              | -              |
| Vegetation         | 56             | -              | 7              | 4              | 4              | -              |
| Fish               | 4              | -              | 4              | -              | 4              | -              |

Parameters Analyzed in each Stage of Analysis

Stage 1 - total uranium, (pH, alkalinity, hardness, T.D.S., for surface and groundwater samples only).

Stage 2 - for water samples Na, K, Ca, Mg, Cl,  $\text{SO}_4$ ,  $\text{PO}_4$ , Fe, Mn, Cu, Pb, Zn, Ni, As

- for soil and sediment samples TKN, total S, Fe, Mn, Cu, Pb, Zn, Ni, As, Th, equivalent  $\text{CaCO}_3$

Stage 3 - total thorium-230, total radium-226

Stage 4 - uranium-234/uranium-238 activity ratio

Stage 5 - uranium-235, protactinium-231, lead-210, polonium-210

Stage 6 - radon-222

The Long Range Mountains are comprised of Late Precambrian granitic rocks and rise from the coastal plain as a very abrupt escarpment to between elevation 465 m and 535 m (see Figure 7). Above the escarpment, the ground surface continues to rise to maximum elevations of 655 m to 673 m. At Falls Lake, the escarpment face is a near vertical cliff that rises approximately 490 m.

The dominant geological feature within the area is the northeast-southwest trending Boundary Fault that has resulted in the uplift of the Long Range Mountains and the development of the pronounced westward facing escarpment. This fault separates the granitic terrain of the mountains from that of the limestone to the west. It passes northeastward through Suitcase Lake and the western shore of Falls Lake.

The glacial deposits within the area are largely sand and gravel that form low ridges of till and kame moraine. These deposits are most prevalent on the coastal plain immediately below the mountains and are frequently overlain by post-glacial peat bogs.

Within the costal plain, fluvial processes have locally reworked the tills into well sorted sand and gravel along the stream courses and beaches have locally formed along the lake shores. Notably, an extensive sand beach occurs along the east shore of Portland Creek Pond. In the mountains, granitic outcrops, thin till veneer and barren peat bogs predominate.

The glacial history of the west coast of Newfoundland was initiated by the Labrador ice sheet which moved southeastward from the mainland. This ice sheet overrode the Long Range Mountains and extended across the entire island of Newfoundland. Toward the end of the Late Wisconsin glacial

period, following the retreat of the Labrador ice sheet, the Long Range Mountains supported an independent ice cap (Grant, 1969a and 1969b). The glaciers moved outward from this ice cap towards the west onto the coastal plain. They locally cut seaward facing, steep sided fjords within the mountains along the west coast of Newfoundland such as Inner Pond of Portland Creek located approximately 4 km south of the study area. In addition to the main Inner Pond fjord, another similar but smaller ice cut feature forms the north-south trending valley that extends from Inner Pond to Falls Lake (see Figure 7). A glacier, moving northward through this valley, deposited the tills and kame deposits around Falls Lake.

The direction of ice movement within the study area is evident from the lithology of the bedrock clasts comprising the till deposits and the orientation of glacial moraine features. The till and kame deposits on the southeast side of the Boundary Fault, including the Falls Lake area, and on the east side of Suitcase Lake and adjacent Three Arm Pond are comprised of granitic materials that correspond to the underlying granitic bedrock. No limestone clasts were observed within these areas. By contrast, on the northwest side of the Boundary Fault, the ground is strewn with both limestone and granitic boulders and the tills have a similar bimodal lithology indicating that the direction of glacial movement was northwestward across the Boundary Fault from the area underlain by granitic bedrock to the limestone terrain. The hummocky moraines in the Falls Lake - Suitcase Lake area are also lineated northwest to southeast parallel to the local direction of ice movement. Distinct east-west trending end moraines also occur around Falls Lake and Three Arm Pond. These features were formed parallel to the front of the

glacier during the period when it retreated southward through the Three Arm Pond valley toward Inner Pond.

Raised beach deposits which extend to elevations of up to 50 m above sea level occur approximately 1 km inland from the east end of Portland Creek Pond. These deposits reflect recessional stages of Portland Creek Pond associated with post glacial uplift within the area.

An extensive deposit of granitic talus has developed on the lower half of the escarpment face overlooking Falls Lake following the deglaciation of the area. The talus extends along the escarpment for 1.2 km as shown on Figure 7. Accumulation of the talus is a continuing process as evidenced by numerous freshly broken surfaces on both the talus boulders and the cliff face and the general lack of vegetation cover. The talus pile occurs in the form of cones extending down from the cliff face with angles of repose varying from 30 to 40 degrees to the horizontal. Due to these steep angles of repose, the talus is unstable and extensive slumping associated with outward movement has occurred along the toe of the pile. A similar situation of instability occurs at the smaller talus pile located 2 km south of Falls Lake (see Figure 7).

### 3.2 Meteorology

The location nearest the study area where climate is monitored by Environment Canada is at Daniels Harbour (see Figure 7). Climate normals are available for Daniels Harbour based on the period 1951 to 1980, which is the current 30 year period for climate normals recommended by the World Meteorological Organization (Environment Canada, 1982). The

mean daily temperature and total precipitation values for the station are summarized on Figure 8.

During the field program (August 18 to 30, 1984), records were kept of minimum and maximum daily temperature and total precipitation. Temperature ranged from 4°C to 26 °C while the average minimum and maximum temperatures were 11.7°C and 20.5°C, respectively. Rainfall occurred on five of the 13 days of record. The largest rain event was 10.4 mm on August 21.

Table 2 presents the data recorded during the field program and the corresponding data from the Daniels Harbour station. The data are similar but indicate that at the study area the maximum temperature may be several degrees higher and precipitation lower relative to Daniels Harbour. Both of these differences probably are related to the study area being approximately 15 km inland and less influenced by the moderating effects of the Gulf of St. Lawrence.

### 3.3 Surface Hydrology - Brucy Brook Basin

The study area is situated within the Brucy Brook drainage basin as shown on Figure 7. The main surface water bodies within the basin are Brucy Brook Pond, Falls Lake, Middle Pond, Suitcase Lake, Three Arm Pond and Underground Pond. Numerous other small ponds also occur throughout the basin.

The total area of the drainage basin is approximately 1050 ha. The basin can be divided into an upper and lower sub-basin of approximately equal areas by the escarpment of the Long Range Mountains.



Brucy Brook Pond is situated within the upper drainage basin and drains via Brucy Brook to Falls Lake. The brook forms a spectacular waterfall where it flows over the escarpment, falling approximately 240 m. In addition to Brucy Brook, Falls Lake receives some water from several small streams that drain the hummocky terrain to the north of the lake and the talus pile on the east side of the lake. Falls Lake discharges to Middle Pond.

The drainage from Three Arm Pond and Suitcase Lake, located within the lower sub-basin, flows into Middle Pond downstream of Falls Lake. The combined flow enters Underground Pond. There is no outfall from Underground Pond and the entire flow of water from the drainage basin is apparently lost via infiltration into highly permeable limestone strata underlying the pond.

The annual discharge of the Brucy Brook drainage basin was estimated from the annual average precipitation data and estimates of the evapotranspiration rates. Based on the most recent 30 year climate normals, total annual precipitation that falls on the drainage basin is 1043.5 mm. Assuming that 50 per cent of this precipitation is lost to evapotranspiration, the total annual discharge from the drainage basin is in the order of  $5.7 \times 10^9$  L. Based on the percentage of the Brucy Brook drainage basin located above Falls Lake, slightly over half of the total basin discharge is expected to pass through Falls Lake. Therefore, the average discharge from Falls Lake is estimated to be approximately 100 L/sec.

Stream flow measurements of Brucy Brook were made between August 10 and 29, at the inlet and outlet of Falls Lake (see Figure 3). The results are summarized on Table 3. The measurements were based on a measured cross sectional area of



TABLE 3

DAILY STREAM FLOW  
BRUCY BROOK AT FALLS LAKE  
AUGUST 18 TO 30, 1984

| Date      | Stream Flow (L/sec) |        | Falls Lake<br>Elevation<br>(m) |
|-----------|---------------------|--------|--------------------------------|
|           | Inlet               | Outlet |                                |
| August 18 | -                   | -      | -                              |
| 19        | 350                 | 850    | -                              |
| 20        | 260                 | 490    | 138.08                         |
| 21        | 360                 | 600    | 138.10                         |
| 22        | 360                 | 600    | 138.10                         |
| 23        | 360                 | 520    | 138.10                         |
| 24        | 230                 | 520    | 138.10                         |
| 25        | 200                 | 510    | 138.07                         |
| 26        | 170                 | 460    | 138.05                         |
| 27        | 200                 | 400    | 138.03                         |
| 28        | 140                 | 360    | 138.04                         |
| 29        | 130                 | 360    | -                              |
| 30        | -                   | -      | -                              |

NOTE: For location of gauging stations, see  
Figure 3 .

the streams and an estimate of the stream velocity. They are considered approximate only.

As indicated in Table 3, the effects of the storm which occurred on August 21 - 22 (15.2 mm of rainfall - see Table 2) are evident in both the measured inflows and outflows for Falls Lake and in the lake water level elevation. The inflow to the lake was estimated to range from approximately 360 L/sec between August 21 and 23 to about 130 L/sec on August 29 and showed a gradually decreasing trend over the measurement period. This latter flow rate (i.e. following the effects of the storm on August 21-22) is generally consistent with the estimated average annual flow.

The outflow from Falls Lake showed a similar decreasing trend over the same period and ranged from about 600 L/sec (August 21-22) to about 360 L/sec (August 28-29). The differences between the flow volumes at the inlet and outlet of Falls Lake are considered to reflect (in their order of importance)

- o a decline in total lake storage (as noted by the decline in the lake level),
- o the presence of small surface inflows around the northern and eastern sides of the lake, and
- o groundwater flow into the lake.

Some part of the difference between the two gauging stations is also due to inherent inaccuracies resulting from the measuring methodology used.

#### 4.0 RESULTS OF 1984 PROGRAM

##### 4.1 Radiation Survey

##### 4.1.1 Background Data

Earlier site investigations by Conwest Exploration and Eldorado Nuclear included gamma radiation surveys of the peat deposit and other features of the general area. These surveys were conducted using scintillometers that produced readings in units of counts per second (cps). Caution must be exercised in comparing the results of surveys expressed in units of cps because scintillometers vary in sensitivity and other operating features.

The results of earlier surveys can be used to loosely characterize the gamma radiation levels of the study area:

- Background levels are in the range of 50 to 70 cps (Clarke, 1978 and Colasurdo, 1979).
- Measurements over limestone are 100 cps or less while those over granite range from 300 to 500 cps (Clarke, 1977).
- Along the talus slope, readings are often in the range of 400 to 800 cps (Clarke, 1978).
- Selected spots in the loamy areas (peat bog) range from 500 to 1200 cps (Clarke, 1977 and 1978).
- Along the top of the escarpment cliff, readings can exceed 1000 cps (Clarke, 1978) while one small magnetite pod has been measured at more than 4000 cps (Clarke, 1977).

Based upon the concentrations of uranium measured at the peat deposit and experience at other deposits, higher gamma radiation levels than those measured would be expected. The relatively low readings made by exploration crews have been interpreted as indicating that the deposit is in disequilibrium; that is, there are not equal amounts of activity for the various decay products of uranium. If a disequilibrium condition exists, radionuclides such as bismuth-214 (the chief gamma radiation emitter detected by scintillometers) would be present in lower than expected amounts at the deposit, thus accounting for the relatively low scintillometer readings (Davenport, 1980).

#### 4.1.2 1984 Program

As discussed in Section 2.3 surface gamma radiation measurements were made using both a SRAT SPP-2 scintillometer (readings in cps) and an Eberline PRM-7 scintillometer (readings in uR/hr). The measurements made with the SPP-2 were similar to those taken previously by exploration crews. Table 4 illustrates this comparison and includes both the 1984 and earlier measurements of gamma radiation along a section of survey line 24+00 N which crosses the deposit.

None of the exploration reports contain readings in units of uR/hr so the measurements made with the PRM-7 cannot be directly compared with earlier studies. Readings were taken at the ground surface at approximately 7.5 m intervals along all of the survey lines. Gamma radiation levels over much of the deposit lie in the range of 20 to 40 uR/hr with some small areas or 'hot spots' between 50 to 100 uR/hr. The measured ranges encountered are in the order of two to ten times higher than background within the study area and also those

TABLE 4

SUMMARY OF GAMMA MEASUREMENTS

| <u>Measurement Locations</u>                           | <u>1984 Measurements</u> |              | <u>Previous Results</u><br>(cps)                 |
|--------------------------------------------------------|--------------------------|--------------|--------------------------------------------------|
|                                                        | <u>(uR/h)</u>            | <u>(cps)</u> |                                                  |
| "background"                                           | 10 to 15                 | 20 to 40     | 50 (Clarke, 1978)                                |
| pieces of core from<br>previous exploration<br>studies | -                        | 100          | typically 125 to<br>160 (Colasurdo,<br>1979)     |
| over "wet" areas of<br>the deposit                     | 25 to 100                | 200 to 600   | 500 (Clarke, 1977)<br>800+ (Clarke, 1978)        |
| granite boulders                                       | 30 to 80                 | 320 to 450   | 300-500 (Clarke, 1977)<br>400-800 (Clarke, 1978) |
| old test pit<br>excavation                             | 200                      | 825          | -                                                |

CPS MEASUREMENTS ALONG A SECTION OF LINE 24+00N

## 1984 Results

|       |            |            |            |                  |            |                          |         |         |     |     |     |     |     |
|-------|------------|------------|------------|------------------|------------|--------------------------|---------|---------|-----|-----|-----|-----|-----|
|       | 150 to 210 | 110 to 210 | 120 to 280 | 150 to 450       | 150 to 500 | 160 to 600               |         |         |     |     |     |     |     |
|       | 160        | 190        | 120        | 200              | 450        | 375                      | 280     |         |     |     |     |     |     |
| open  | 6 +00E     | 7 +00E     | 8 +00E     | damp area 9 +00E | dry ridge  | flooded 10 +00E          | 11 +00E | 12 +00E |     |     |     |     |     |
| swamp |            |            |            |                  | area       | increasingly steep slope |         |         |     |     |     |     |     |
|       | 100        | 95         | 140        | 90               | 95         | 90                       | 210     | 160     | 300 | 100 | 225 | 160 | 225 |

Previous Results (from Colasurdo, 1979)



commonly encountered in North America. The gamma radiation data obtained from the site is contoured in 10 uR/hr intervals on Figure 9. All of the areas where the gamma radiation over soil deposits is in excess of 30 uR/hr (approximately twice background) occur in areas of peat bog and were relatively damp or inundated.

At approximately 30 m (100 foot) intervals, gamma radiation measurements were taken at 1 m above ground level as well as at the ground surface. Where surface values were relatively low (generally 25 uR/hr or less), the 1 m level readings were little different (usually 0 to 2 uR/hr lower). Where surface readings were relatively high (75 uR/hr or more), the waist height readings were as much as 50 uR/hr lower. These large differences are consistent with the finding that such surface "hot spots" are quite small and usually less than a few metres in diameter.

The PRM-7 measurements were also used to obtain gamma radiation profiles in the test pits dug during the field program. Some of these pits produced readings of 400 uR/hr at certain depths, although these values may have been somewhat exaggerated by the mass affect of emmissions from the nearby pit walls and floors. However, several test pits showed a distinct trend of increasing radiation with depth in the peat, and a sharp decrease in radioactivity in the underlying mineral soil. The highest radiation levels were generally encountered below the watertable. The profiles for the test pits are presented on the Record of Test Pits in Appendix A.

While providing considerably more detail about radiation levels around the peat deposit, the 1984 program largely confirmed the conclusions of earlier studies, the most notable being the relatively low gamma radiation levels considering the amount of uranium present (see Section 4.4.1). Organic materials rich in uranium but with scintillometer-detectable radiation levels little different than surrounding rocks have been reported in British Columbia in areas with emergent springs (Culbert, 1979).

## 4.2 Subsurface Stratigraphy

### 4.2.1 Overview

The boreholes and test pits put down in the study area encountered three major soil types, including organic soils, sand and gravel till, and alluvial sand and gravel. These soils were found to overlie granite bedrock.

Detailed descriptions of the soils and bedrock are included in the Record of Boreholes and Record of Test Pits in Appendix A. The stratigraphic relationships are shown in section on Figure 10.

As indicated on Figure 10, the site is underlain at a depth of about 2 m to 5 m by granitic bedrock which rises to form the Long Range Mountains immediately to the east of the site. The bedrock is overlain by dense granular till which is comprised predominantly of sand and gravel with some boulders. Outside the toe of the talus slope which is inferred to lie directly on the till, the upper surface of the till is hummocky to gently undulating with the topographic depressions infilled with shallow (typically less than about 1.5 m thick)

and, in the area of Brucy Brook, shallow alluvial sands and silts.

#### 4.2.2 Organic Soils

The organic soils encountered at the site consist mainly of sphagnum peat and grassy marsh peat. As indicated on Figures 11 (Plan) and 10 (Section), the sphagnum peat occurs over much of the study site but has accumulated most extensively within a peat bog located between Falls Lake and the toe of the talus pile. The bog is subdivided into three separate areas by a central ridge of till moraine (Figure 11). The total area of peat bog is approximately 1.9 ha. The peat was found to vary in thickness from 0.25 to 1.5 m as shown on Figure 11. Maximum thicknesses of 1.75 m were encountered near BH-1. Based on the depth contours shown on Figure 11, it is estimated that the total volume of peat in the deposit is of the order of 13,000 m<sup>3</sup>.

The peat bogs have relatively flat surfaces that gently slope towards Falls Lake. Ponded water or saturated surface conditions indicated poor surface drainage. The bogs are also densely wooded with coniferous and birch trees 3 to 5 m in height.

The peat bogs have accumulated within depressions between the till moraine ridges that cross the site as shown in section on Figure 10. The central till moraine ridge separates the bogs into an upper and lower terrace.

Detailed examination of the peat was carried out in nine test pits, three boreholes and numerous hand auger probes. The upper 0.1 to 0.2 m of the bog was found to be comprised

of green to yellow sphagnum moss. At surface, the moss is actively growing but becomes progressively decayed below the depths of 0.1 to 0.2 m. Below these depths the peat is saturated, very dark brown to black, soft to firm, very fine grained, and humified. It contains numerous buried roots and stumps of dead coniferous trees. The roots and stumps were encountered throughout the full thickness of the peat although they became less prevalent with depth.

The moisture content, ash content and organic content of the 10 peat samples are summarized in Table 5. The moisture content of the peat is very high, varying from 238 to 780 per cent and averaging 500 per cent by weight\*. The organic content of the peat varies from 10 to 19 per cent, averaging 14 per cent. The ash component, which largely reflects mineral soil, is very low, ranging from 0.9 to 3.5 per cent except for Sample 2 of Test Pit 2 where the ash content was 16.35 per cent. This sample is situated at the foot of the till moraine ridge that runs through the centre of the site. It is likely that the ridge contributed mineral sediment from runoff as the peat accumulated.

The sphagnum peat thins to less than 0.25 m within the elevated areas of better drainage adjacent the bogs, notably the moraine ridges. The peat within these areas has accumulated from rotting leaf and wood material from the forest in addition to sphagnum moss and consequently is more representative of forest humus. It is reddish brown in colour and appears much drier, less compacted and lighter by weight than the wet humified peat from the bogs.

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\* Moisture content is the weight of water divided by the weight of dry soil expressed as a per cent.

TABLE 5

MOISTURE, ASH AND ORGANIC CONTENTSOF PEAT

| Sample No. | Constituents - 100% Total Sample |          |              | Moisture<br>Content * |
|------------|----------------------------------|----------|--------------|-----------------------|
|            | Moisture<br>%                    | Ash<br>% | Organic<br>% |                       |
| TP1 SA#1   | 87.54                            | 1.58     | 10.88        | 703                   |
| TP2 SA#2   | 70.37                            | 16.35    | 13.28        | 238                   |
| TP3 SA#3   | 83.67                            | 2.26     | 14.07        | 512                   |
| TP4 SA#1   | 74.30                            | 2.19     | 23.51        | 289                   |
| TP5 SA#1   | 80.87                            | 1.60     | 17.53        | 423                   |
| TP6 SA#3   | 88.61                            | 1.02     | 10.37        | 778                   |
| TP7 SA#4   | 81.46                            | 0.87     | 17.67        | 439                   |
| TP8 SA#4   | 77.91                            | 3.48     | 18.61        | 353                   |
| TP9 SA#1   | 87.36                            | 1.66     | 10.98        | 691                   |
| TP10 SA#1  | 85.27                            | 1.64     | 13.09        | 579                   |

\* Moisture content is weight of water divided by weight of dry soil expressed as a percent.



One sample of the forest humus was analyzed from Test Pit 4 (Sample 1) and the results, shown in Table 5, indicate that the overall composition is similar to the bog peat although the organic content is higher (23.51 per cent).

Marsh peat, as opposed to the sphagnum peat discussed above, has accumulated on the alluvial plain of Brucy Brook immediately south of Falls Lake (see Figure 11). This peat is reddish brown in colour and has accumulated largely from the decay of marsh grasses. It appears much more fibrous as compared to the highly decomposed black sphagnum peat.

The marsh peat was found to be rather thin varying in thickness from 0.2 to 0.7 m along Line 24+00. The profile shown on Figure 10 indicates that the thicker accumulations of this peat have occurred in depressions in the alluvium, possibly representing old meander channels of Brucy Brook.

#### 4.2.3 Sand and Gravel Till

Sand and gravel till is the most extensive surficial deposit. It underlies the peat bog areas and forms moraine ridges within the site. The till was encountered in all of the boreholes and was found to vary in thickness from 1.4 to 4 m. As indicated on Figure 10, the till directly overlies bedrock.

The till is a dense to very dense, brown to grey-brown gravelly sand to sand and gravel containing a trace to some silt and occasional boulders. Grain size distribution curves for 13 till samples collected from the test pits and boreholes are shown on Figures A-1, A-2 and A-3 in Appendix A. The curves indicate the tills are moderately well graded.



Boulders encountered in test pits were subangular to sub-rounded in shape and varied up to 0.5 m in diameter. The lithologies of the boulders were predominantly granite and granitic gneiss but occasionally varied to weathered amphibolite and schist.

The mineralogy of the clay size fraction (  $2\text{ }\mu\text{m}$ ) of the tills was determined by testing seven (7) samples using x-ray diffraction methods (for analytical methods and results, see Appendix A). Clay minerals, predominately chlorite and illite, comprise the largest fraction of the samples with feldspar and quartz being the next most common minerals. The mineralogy of the clay size fraction is characteristic of detritus derived from unweathered granite and gneiss terrain similar to that of the Long Range Mountains. Detailed percentages of the minerals present are summarized in Table A.1 of Appendix A.

#### 4.2.4 Alluvial Sand and Gravel

Alluvial deposits form the Brucy Brook streambed and underlie the surrounding flat marshy areas and much of Falls Lake. The deposits are post glacial and were derived from fluvial reworking of the till by Brucy Brook. The alluvium was found to be 1.4 m thick in Borehole 4 (see Figure 10). The alluvium consisted of loose, brown to grey-brown sand to silty sand with a trace to some gravel. A grain size analysis of one alluvium sample collected from Borehole 4 (sample 2) indicates that the material is poorly graded (see Figure, A-4 Appendix A).

A thin, 2 cm, layer of laminated clayey silt alluvium was encountered in Test Pit 3 (sample 5) separating the peat from the underlying till. This layer suggests that the peat has filled depressions that may have been former areas of ponded water on the lower terrace.

#### 4.2.5 Bedrock

Granite bedrock underlies the entire study area. It was encountered in Boreholes 1, 2 and 3 at depths of 4.8, 2.7 and 2.6 m, respectively. The granite encountered in the boreholes was generally fresh but exhibited some faint to moderate weathering on joints and fractures. The dominant mineralogy was pink feldspar and quartz. Sheared surfaces and brecciated sections of the core were coated with chlorite and some calcite mineralization. Traces of purple fluorite were also noted.

A small outcrop of granite similar to that encountered in the boreholes was observed on the east shore of Falls Lake. The granite also comprises the cliff that rises above the site and outcrops along the east shore of Suitcase Lake. Limestone was observed at outcrops along the west shore of Suitcase Lake and is considered to underlie the till deposits on the west shore of Falls Lake. The limestone dips westward at 10 to 30 degrees and it is separated from the granite by the Boundary Fault which runs through the length of Suitcase Lake (see Figure 7).

#### 4.3 Hydrogeology

##### 4.3.1 Groundwater Flow

The site is situated in a groundwater discharge zone at the base of the escarpment as noted by the occurrence of a prominent line of springs located along the toe of the talus pile (see Figure 11). Groundwater emerges along these springs and runs off the site as surface drainage through the peat bogs.

The position of the watertable is shown in section along Line 24+00 north (see Figure 10). It was found to vary from 0.1 to 0.4 m below ground surface beneath the areas of bog and was at a depth of up to 1.5 m beneath the till moraine ridges.

The watertable slopes westward, dropping 6.2 m from Borehole 1 to the level of Falls Lake. The corresponding horizontal hydraulic gradient is approximately 4.6 per cent. The groundwater levels within the surficial deposits and the underlying bedrock were found to be approximately the same indicating that there was no significant vertical hydraulic gradient at the time of the investigation. However, it is suspected that, at least seasonally, local upward gradients may result in groundwater discharge into the up-gradient portions of the bogs.

Based on the hydraulic gradient, groundwater flow is largely horizontal from the line of spring along the toe of the talus towards Falls Lake as shown schematically on Figure 10. The major area of groundwater recharge to the flow system is considered to be the highly permeable talus located up-gradient from the site. Rainfall and snowmelt will readily infiltrate the talus and flow down-gradient toward the study site and Falls Lake. It is considered that all groundwater flowing in the surficial deposits beneath the site will discharge into Brucy Brook or Falls Lake.

It is estimated that approximately  $7.5 \times 10^7$  L/yr of precipitation falls in the talus above the peat. Assuming 50 per cent is lost to evaporation, the flux of water discharging from beneath the talus to the peat bog is in the order of  $3.75 \times 10^7$  L/yr. Much of this would run off the bog as surface drainage.

#### 4.3.2 Hydraulic Conductivity

Falling and rising head tests were conducted in piezometers P1-1, P1-2, P2-1 and P2-2 to assess the hydraulic conductivity of the soil and rock. A bailer was used to attempt to draw down the water levels in the piezometers. However, the recovery was so rapid in P1-1 (bedrock) and P1-2 (till) that sufficient recovery data could not be obtained for detailed analysis (i.e. it is known only that the hydraulic conductivity was greater than about  $10^{-3}$  cm/sec). Limited recovery data was obtained for piezometers P2-1 (bedrock) and P2-2 (peat and top of till). The hydraulic conductivity of the former was estimated at  $7 \times 10^{-4}$  cm/sec while the peat was lower, approximately  $8 \times 10^{-6}$  cm/sec.

Indications of the permeability of the surficial deposits was obtained during the excavation of the test pits. Only minor groundwater inflows were experienced while digging in the peat below the watertable indicating the material has a low permeability. However, rapid flooding was experienced in Test Pits 1, 6 and 9 when the contact between the peat and underlying sand and gravel till was encountered. The large volumes of water appeared to originate from beneath the peat. In addition, during the drilling of Borehole 2, near Test Pit 1, all the drill water and surrounding surface water was noted to rapidly drain down the borehole to a standing water level coincident with that of the watertable. It was concluded that the sand and gravel at the peat contact beneath these four sites was very permeable. Elsewhere within the site, groundwater seepage into the test pits from the underlying gravel was slow, reaching a static level within a few hours or overnight.



#### 4.4 Geochemistry

##### 4.4.1 Soil Chemistry

The soil samples included both samples of the organic peat and the underlying mineral soil. The results of the geochemical analyses of the soil samples including major elements and radionuclides are given in Table B-3 of Appendix B and uranium analyses are given in Table B-4 Appendix B. Measured ranges of major element chemistry and radionuclides in the mineral and organic soils encountered at the site are summarized in Tables 6, 7 and 8.

The major element analyses indicate that the concentrations of total kjeldahl nitrogen (TKN) and total sulphur are up to ten times higher in the organic soils than in the underlying mineral soils (see Table 6). In addition the concentrations of these constituents are higher within the peat bog samples than in the forest humus.

The concentration of heavy metals, excluding thorium and uranium, are somewhat lower within the organic soils than in the mineral soils. However the overall minimum-maximum ranges are similar (see Table 6). The concentrations of the heavy metals are within the expected range for soils (Lindsay, 1979). The concentration of calcium bicarbonate ( $\text{CaCO}_3$ ) within the mineral soils is low (0.3 to 1.3 per cent) and is characteristic of material derived from granitic terrain. The concentration is somewhat higher in the organic soils, varying from 1.3 to 7.5 per cent.

As indicated in Table 6, the concentration of thorium was found to be higher in the peat bog samples (4 to 440 ppm)

TABLE 6

RANGES OF MAJOR ELEMENT CHEMISTRYSOIL

| Constituent             | MINIMUM - MAXIMUM CONCENTRATIONS |             |                      |                 |
|-------------------------|----------------------------------|-------------|----------------------|-----------------|
|                         | Mineral Soil                     |             | Organic Soil         |                 |
|                         | Silt                             | Sand        | Sphagnum<br>Peat Bog | Forest<br>Humus |
| TKN            ppm as N | 670 - 1270                       | 201 - 435   | 33 - 19700           | 9060 - 10300    |
| Total Sulphur   ppm     | <75 - 270                        | <75         | 2600 - 7500          | 930 - 1100      |
| CaCo3 Equiv.    %       | 0.3 - 1.3                        | 0.5 - 0.7   | 1.3 - 7.5            | 0.6 - 2.0       |
| Fe                ppm   | 19.8 - 47.4                      | 13.2 - 15.3 | 1.3 - 11.0           | 1.0 - 4.5       |
| Cu                ppm   | 40.5 - 178                       | 16.6 - 18.8 | 5.3 - 107            | 3.0 - 6.2       |
| Mn                ppm   | 560 - 630                        | 290 - 380   | 6.7 - 435            | 38.5 - 198      |
| Ni                ppm   | 4.2 - 10.1                       | 22.5 - 34.0 | 1.6 - 8.9            | 1.1 - 2.5       |
| Pb                ppm   | 21.9 - 38.4                      | 16.4 - 19.8 | <5 - 45.0            | 7.0 - 28.5      |
| Zn                ppm   | 56.0 - 180                       | 43.1 - 46.1 | 6.2 - 63.3           | 33.2 - 47.2     |
| As                ppm   | <50 - 53                         | <50         | <50 - 116            | <50             |
| Se                ppm   | -                                | -           | <10 - 13             | -               |
| Mo                ppm   | -                                | -           | 3.5 - 30.2           | -               |
| V                 ppm   | -                                | -           | 22.6 - 66.2          | -               |
| Th                ppm   | 12.3 - 63.8                      | 6.0 - 16.7  | <4 - 440             | 4.0 - 9.0       |



TABLE 7

RANGES OF URANIUM CONCENTRATIONSSOIL

| Sample Type         | Minimum and Maximum Concentrations - Uranium ppm |            |            |                     |              |
|---------------------|--------------------------------------------------|------------|------------|---------------------|--------------|
|                     | <u>Mineral Soil</u>                              |            |            | <u>Organic Soil</u> |              |
|                     | Silt                                             | Sand       | Gravel     | Sphagnum Peat Bog   | Forest Humus |
| Borehole Samples    | 45.0 - 2150                                      | 8.5 - 54.3 | 7.0 - 12.0 | 70.2 - 24500        | -            |
| Test Pit Samples    | 13 - 1490                                        | 7.7 - 246  | 5.5 - 6.9  | 192 - 28100         | 2.5 - 6.6    |
| Auger Probe Samples | 10.8 - 5680                                      | 4.5 - 262  | -          | -                   | -            |

TABLE 8

RANGES OF RADIONUCLIDE ACTIVITIESSOIL

| Radionuclide | MINIMUM - MAXIMUM ACTIVITIES |                 |                                       |                 |
|--------------|------------------------------|-----------------|---------------------------------------|-----------------|
|              | <u>Mineral Soil</u>          |                 | <u>Organic Soil</u>                   |                 |
|              | Silt                         | Sand            | Sphagnum<br>Peat Bog                  | Forest<br>Humus |
| Ra-226 Bq/g  | $3.51 \pm 0.10$              | $0.71 \pm 0.06$ | $0.475 \pm 0.040$<br>- $14.9 \pm 0.3$ | -               |
| Th-230 Bq/g  | $1.34 \pm 0.05$              | $0.24 \pm 0.03$ | $0.084 \pm 0.012$<br>- $11.1 \pm 0.2$ | -               |
| U-235 Bq/g   | -                            | -               | $10 \pm 1$ - $14 \pm 3$               | -               |
| Pa-231 Bq/g  | -                            | -               | $0.12 \pm 0.02$<br>- $0.50 \pm 0.05$  | -               |
| Pb-210 Bq/g  | -                            | -               | $2.04 \pm 0.18$<br>- $5.4 \pm 0.4$    | -               |
| Po-210 Bq/g  | -                            | -               | $2.4 \pm 0.2$<br>- $6.3 \pm 0.4$      | -               |
| U-234/U-238  | -                            | -               | $0.92 \pm 0.05$<br>- $1.26 \pm 0.05$  | -               |

than in the underlying mineral soil (6.0 to 63.8 ppm). The concentration of thorium in the mineral soils also tends to be highest within the silt size fraction.

The concentrations of uranium in the soil samples was found to vary from 2.5 to 28100 ppm based on the dry weight of the sample. The highest uranium concentrations were encountered in the sphagnum peat bog where they range from 70 to 28100 ppm (see Table 7).

The concentration of uranium within the mineral soil samples from beneath the peat varied from 5.5 to 2150 ppm; the highest concentrations being encountered near the peat contact. The uranium concentrations of the mineral soils from the auger probes were higher, varying from 10.8 to 5680 ppm. Based on the borehole samples, the maximum concentrations within the deeper soils varied from 7.7 to 67.8 ppm. Within each soil sample, the highest uranium concentrations were associated with the silt size fraction. Some mineral soil samples, particularly the auger probe samples, contained peat due to sampling. It is considered that the unavoidable peat contamination of these samples is responsible for the high uranium concentrations and consequently the values obtained are more probably representative of the overlying peat. Samples of gravel sized rocks taken from the boreholes and test pits had uranium concentrations of 5.5 to 12 ppm (see Table 7).

The highest uranium concentrations (5000 to 28,000 ppm) were encountered in the boreholes and test pits put down in the upper peat bog in the area along the base of the talus pile between Lines 22+00 and 26+00 North. These areas of high uranium concentration also correspond to the gamma radiation

anomalies shown on Figure 9. The surface drainage originating from the line of springs at the toe of the talus also flows through this area. By comparison uranium concentrations in the lower peat bog varied from 1000 to 4000 ppm, being highest in the deeper, east side of the bog.

The uranium concentrations within the peat were noted to increase with depth (see Record of Test Pits, 5, 8, 9, 10). In Test Pits 5, 8, and 9 a sharp increase in uranium occurs below the watertable. The sharp increase may be associated with the very strong reducing conditions associated with saturated peat. Uranium carried in solution will tend to precipitate under these conditions. In the mineral soil underlying the peat, the concentration of uranium sharply decreases to less than 1500 ppm. These patterns of uranium concentration are closely reflected by the vertical profiles of gamma radiation in the peat as shown on the Records of Test Pits (i.e. Test Pit 5).

The total amount of uranium within the peat deposit has been estimated on the bases of the analytical results and the estimated volumes of peat (see Section 4.2.2). The average concentration of uranium within the peat bog of the upper terrace is considered to be 10,000 ppm (dry weight). Assuming a wet bulk density of the peat of  $1.1 \text{ tonne/m}^3$  and an average water content of 500 per cent by weight the estimated amount of uranium with this bog is approximately 12 tonnes. The average concentration of uranium in the lower terrace peat bog is considered to be approximately 1500 ppm and the amount of uranium is estimated at approximately 1.4 tonnes. Assuming similar concentrations for the bog around Big Rock Pond, the amount of uranium within this bog would be approximately 1 tonne. The above average uranium concentrations and

estimated total tonnage within the deposit is similar to that determined by Eldorado Nuclear Ltd. (Colasurdo, 1979). They estimated a maximum uranium content of 21 tons (19.1 tonnes) and an average concentration of 6597 ppm for the entire deposit. Similar types of uranium occurrences associated with post-pleistocene peat deposits were described in south central British Columbia by Levinson et al, 1984. However, in these deposits the concentrations of uranium were lower ranging from 12 to 1620 ppm.

Rock samples from the talus pile on Line 24+00N uphill from the peat deposit were previously analysed by Eldorado Nuclear Ltd. (Colasurdo, 1979). The samples of granite had uranium concentrations of 50 to 60 ppm and similar concentrations of thorium. Assay results from granite cored in diamond drill holes as part of the Eldorado Nuclear exploration program indicated that the rock contains from 10 to 90 ppm uranium with a maximum concentration of 200 ppm reported. The results also indicated that the rock contains thorium concentrations of 50 to 160 ppm.

The activity of radium-226 and thorium-230 in the peat samples varied from 0.475 to 14.9 Bq/g and 0.084 to 11.1 Bq/g, respectively. (see Table 8). Based on the low activities of Th-230, which coincide with concentrations of  $1.16 \times 10^{-2}$  ppm, most of the thorium present in the deposit (4 to 440 ppm - see Table 6) occurs as Th-232.

The activities of radium-226 and thorium 230 are quite similar for each sample, suggesting their ingrowth as radiogenic daughters of uranium decay. The activities of radium-226 and thorium-230 tends to be lower in the mineral soils based on one sample. The activities of lead-210 and polonium-210 are also quite similar to thorium-230 and radium-226, again suggesting their ingrowth by decay of U-238.



The activities ratio of U-234/U-238 in the uraniumiferous peat samples varied from 0.92 to 1.26 averaging 1.13. These ratios are considered consistent with a deposit that has formed from the precipitation of dissolved uranium in groundwater (Levinson et al, 1984). The uranium-234 tends to be more soluble than U-238 due to the ejection of the U-234 daughter from the uranium bearing mineral by the effect of mass recoil when U-238 decays. When the uranium derived from the mineralized source is subsequently precipitated it will retain the same elevated U-234/U-238 ratio. Based on the uranium concentrations in the granitic rock forming the talus slope, leaching of uranium from the talus by rain water and snow melt could provide the source of the uranium subsequently precipitated within the peat bog.

#### 4.4.2 Groundwater Chemistry

The results of chemical and radiological analyses carried out on samples of groundwater from the site area are given in Table B-6 of Appendix B and are summarized in Tables 9 and 10. The groundwater obtained from piezometers and groundwater springs was found to be very soft and mildly acidic, characteristic of granitic terrain and bog. The TDS and pH varied from 30 to 138 mg/L and 4.87 to 6.28, respectively (see Table 9). The lower pH conditions (4.9 to 5.7) tend to be associated with groundwater obtained from the bog, whereas the higher pH water tends to occur in the underlying soils and talus springs.

The dominant dissolved constituents in the groundwater are sodium (2.5 to 19.6 mg/L), bicarbonate (10 to 42 mg/L) and chloride (4.2 to 7.1 mg/L). The dominance of sodium as the major cation is considered to result from the influence of precipitation within a coastal marine environment.

TABLE 9

RANGES OF MAJOR ELEMENT CHEMISTRYGROUNDWATER

| Constituent     |                           | Minimum and Maximum Concentrations |
|-----------------|---------------------------|------------------------------------|
| Ph              |                           | 4.87 - 6.28                        |
| Bicarbonate     | mg/L as HCO <sub>3</sub>  | 10 - 42                            |
| Hardness        | mg/L as CaCO <sub>3</sub> | 2 - 23                             |
| Conductivity    | umho/cm                   | 39 - 93                            |
| TDS             | mg/L                      | 30 - 138                           |
| Ca              | mg/L                      | <0.7 - 5.3                         |
| Mg              | mg/L                      | <0.1 - 1.1                         |
| Na              | mg/L                      | 2.5 - 19.6                         |
| K               | mg/L                      | <0.2 - 1.8                         |
| SO <sub>4</sub> | mg/L                      | 1.5 - 6.6                          |
| Cl              | mg/L                      | 4.2 - 7.1                          |
| Phosphate-Ortho | mg/L                      | <0.01 - 0.09                       |
| As              | mg/L                      | <0.01                              |
| Cu              | mg/L                      | <0.016                             |
| Fe              | mg/L                      | 0.019 - 5.940                      |
| Mn              | mg/L                      | 0.002 - 0.160                      |
| Ni              | mg/L                      | <0.01 - 0.02                       |
| Pb              | mg/L                      | <0.03 - 0.05                       |
| U               | mg/L                      | 0.0295 - 0.715                     |
| Zn              | mg/L                      | 0.007 - 0.239                      |

TABLE 10

RANGES OF RADIONUCLIDE ACTIVITY  
GROUNDWATER

| Constituent |      | Minimum and Maximum Activities        |
|-------------|------|---------------------------------------|
| Ra-226      | Bq/L | $0.006 \pm 0.003$ - $0.190 \pm 0.005$ |
| Th-230      | Bq/L | $<0.005$ - $0.145 \pm 0.004$          |
| U-235       | Bq/L | $0.13 \pm 0.05$ - $0.41 \pm 0.05$     |
| Pa-231      | Bq/L | $\leq 0.005$                          |
| Pb-210      | Bq/L | $0.42 \pm 0.04$ - $1.32 \pm 0.11$     |
| Po-210      | Bq/L | $0.24 \pm 0.05$ - $0.79 \pm 0.20$     |
| U-234/U-238 |      | $1.03 \pm 0.05$ - $1.37 \pm 0.05$     |

Heavy metal concentrations were generally at or below the detection limits although iron and manganese varied up to 6 mg/L and 0.16 mg/L respectively (see Table 9). Compared to the other heavy metals (Cu, Pb, Zn, and Ni), the concentration of uranium was high, 0.03 to 0.7 mg/L. The concentration of uranium in spring water emerging from the talus was 0.03 to 0.05 mg/L.

The activity of dissolved radium-226 in the groundwater was low, varying from 0.006 to 0.190 Bq/L (see Table 10). The activity of thorium-230 was similarly low at 0.005 to 0.145 Bq/L.

The ratio of U-234 to U-238 varied from 1.03 to 1.37. These results are consistent with those of the peat samples (see above) and with ranges determined for the local surface water (see Section 4.5.1).

#### 4.4.3 Radon in Groundwater

Previous exploration efforts in the study area did not include any direct measurements of radon-222 in groundwater; however, radon monitors had been placed in the ground at various locations to measure radon in soil gas. From the data generated by these monitors, several conclusions regarding groundwater have been offered.

- . Groundwater seeps and springs are characterized by high uranium and probably high radon activities (Davenport, 1980).
- . Anomalous radon monitor results are clearly related to the radon and uranium bearing waters that drain through the broken granite in the talus located at the foot of the cliff (Clarke, 1978).

- . The poor agreement observed between 1976 and 1977 monitors placed at very similar locations was attributed to the highly variable influence of radon levels in groundwater and springs (Clarke, 1979).

Based on the general behaviour of radon in water and on the conditions observed in the field during the 1984 program, certain locations were expected to produce higher radon activities than others. For example, higher activities were anticipated from the piezometers in the vicinity of the peat deposit than in those located downgradient (farther west). Similarly, activities in surface water (such as Brucy Brook) were expected to rapidly decline with distance from the peat deposit due to the release of radon to the atmosphere.

The results of radon analyses in both surface water and groundwater samples obtained during the 1984 study are summarized in Table 11. The measurements follow the anticipated pattern noted above. The activities observed in groundwater samples obtained from both the granite and overburden beneath the deposit (700 to 1000 Bq/L) lie toward the upper end of the ranges observed in many parts of the world (Butler, 1980), but values as high or higher have been measured in parts of eastern North America (U.S. EPA, 1977).

The water that collected in the test pits possibly had radon activities as high as those measured from the piezometers prior to emerging into the pits. However, release upon contact with the atmosphere would rapidly lower radon levels. In an attempt to reduce the influence of radon release to the atmosphere, samples were taken well below the surface of the water in the pits. Similarly, springs were sampled at locations where the ground water appeared to be emerging. However, significant radon release probably occurred despite



TABLE 11

RADON MEASUREMENTS IN GROUNDWATER AND SURFACE WATER

| <u>Sample Location and Characteristics</u> |                                                           | <u>Activities<br/>(Bq/L)</u> |
|--------------------------------------------|-----------------------------------------------------------|------------------------------|
| <u>Groundwater at Depth</u>                |                                                           |                              |
| Piezometer 1-1                             | (in granite, below<br>centre of deposit)                  | 754, 724                     |
| Piezometer 1-2                             | (middle of overburden)                                    | 1037, 1079                   |
| Piezometer 3-1                             | (bottom of overburden,<br>probably outside of<br>deposit) | 161, 174                     |
| Piezometer 4-1                             | (in till overburden<br>outside of deposit)                | 173, 177                     |
| <u>Emergent Groundwater</u>                |                                                           |                              |
| Test Pit 5                                 | (in relatively "high"<br>radiation area)                  | 239, 253                     |
| Test Pit 8                                 | (on edge of main part<br>of deposit)                      | 224, 191                     |
| Test Pit 10                                | (in relatively "high"<br>radiation area)                  | 248, 247                     |
| Spring 26                                  | (emerges at base of<br>talus)                             | 180, 175                     |
| Spring 28                                  | (emerges at base of<br>talus)                             | 194, 192                     |
| <u>Surface Water</u>                       |                                                           |                              |
| L24 Creek Station #1                       | (near centre of deposit)                                  | 116, 115                     |
| L24 Creek Station #2                       | (near edge of deposit)                                    | 38, 34                       |
| Brucy Brook                                | (mouth)                                                   | <4, <4                       |

these efforts. This fact notwithstanding, the consistency of the results for the pairs of samples demonstrate the reproducibility of the sampling and analytical method.

The rapid release of radon to the atmosphere is further evidenced by the surface water activities measured at two stations about 60 m apart on the stream that crosses the deposit (Stream L24 - see Figure 5 for location). Within this distance (travel time was estimated at 10 minutes), radon levels declined 65 to 70 per cent. As expected, the lowest activities were found in Brucy Brook.

In summary, the measured radon levels suggest either the presence of a low grade source or a young uranium source in disequilibrium with its decay series. Westward migration of radon in the overburden appears to be largely diminished after passing the deposit area. Groundwater emerges at several locations in and around the deposit. Upon exposure to the atmosphere, the radon is rapidly released to the atmosphere, resulting in radon levels in the surface waters several orders of magnitude lower than those in the groundwater.

#### 4.5 Surface Water Sediment Chemistry

##### 4.5.1 Surface Water

Surface streams within the peat deposit area originate along a line of springs located at the toe of the talus pile from where they flow downslope, either to Brucy Brook or Falls Lake (see Figure 5). Drainage is poor within the areas underlain by peat bog and localized ponding of water occurs.

A central ridge within the deposit separates the site drainage into two main streams. The larger stream (Creek L24 - see Figure 5) emerges from the talus pile between lines 24+00N and 26+00N and flows southwest to Brucy Brook. The other smaller stream (Creek L 28) flows northwest from Big Rock Pond to Falls Lake. The flow rates within these streams, based, on visual estimates, are in the order of 0.5 to 2.0 L/s.

Previous exploration efforts in the study area included some sampling of local streams and springs, although most of the samples were deliberately gathered to determine the quality of emergent groundwater (Clarke, 1978). The few pH measurements that were made ranged from 4.9 to 5.5 while uranium concentrations were generally less than 20 ppb (ug/L) with a maximum reported value of 80 ppb (Clarke, 1978).

As part of the 1984 field program, surface water samples were obtained for subsequent laboratory analysis at ten stations within the general study area (see Section 2.5.1 for sampling procedures and Figure 5 for sampling locations). The results of the chemical and radiological analyses are presented in Tables C-3 and C-4 of Appendix C and are summarized in Tables 12 and 13.

Measurements of pH in the field and in the laboratory indicate that the surface waters in Brucy Brook, Falls Lake and the bog area were slightly acidic (pH values usually in the range of 5.4 to 5.9). However, Suitcase Lake, which is part of a different drainage area and is underlain by limestone bedrock, is less acidic (pH values of 6.5 to 6.7). The most acidic measurements were in the western arm of Brucy Brook (pH of 4.4 to 4.6).

TABLE 12

RANGES OF MAJOR ELEMENT CHEMISTRYSURFACE WATER

|                 |                         | Minimum and Maximum Concentrations |                               |                  |
|-----------------|-------------------------|------------------------------------|-------------------------------|------------------|
| Constituent     |                         | Peat Deposit                       | Brucy Brook<br>and Falls Lake | Suitcase<br>Lake |
| pH              | (field and lab)         | 5.40 - 6.29                        | 4.40 - 6.68                   | 6.5 - 6.68       |
| Bicarbonate     | mg/L as $\text{HCO}_3$  | 10 - 18                            | 5                             | 15               |
| Hardness        | mg/L as $\text{CaCO}_3$ | 11 - 21                            | 3 - 10                        | 13 - 14          |
| Conductivity    | $\mu\text{mhos/cm}$     | 21 - 53                            | 19 - 32                       | 44 - 54          |
| TDS             | mg/L                    | 26 - 58                            | 14 - 40                       | 36 - 70          |
| <hr/>           |                         |                                    |                               |                  |
| Ca              | mg/L                    | 1.6 - 2.7                          | <0.5 - 0.7                    | 1.9              |
| Mg              | mg/L                    | <0.05                              | <0.05                         | <0.05            |
| Na              | mg/L                    | <0.02 - 0.45                       | <0.02 - 0.7                   | 1.6              |
| K               | mg/L                    | <0.1 - 0.3                         | <0.1 - 0.2                    | 0.2              |
| $\text{SO}_4$   | mg/L                    | 3.2 - 10.7                         | 1.7 - 2.0                     | 3.0              |
| Cl              | mg/L                    | 4.5 - 5.4                          | 2.5 - 2.7                     | 5.7              |
| <hr/>           |                         |                                    |                               |                  |
| Phosphate-Ortho | mg/L                    | <0.01                              | <0.01                         | <0.01            |
| As              | mg/L                    | <10                                | <10                           | <10              |
| Cu              | mg/L                    | <0.02                              | <0.02                         | <0.02            |
| Fe              | mg/L                    | 0.044 - 0.32                       | 0.11 - 0.15                   | 0.22             |
| Mn              | mg/L                    | <0.001 - 0.006                     | 0.003 - 0.006                 | 0.009            |
| Ni              | mg/L                    | <0.01                              | <0.01                         | <0.01            |
| Pb              | mg/L                    | <0.03                              | <0.03                         | <0.03            |
| Zn              | mg/L                    | <0.002                             | <0.002 - 0.064                | 0.076            |

TABLE 13

RANGES OF URANIUM CONCENTRATIONS AND  
RADIONUCLIDE ACTIVITIES  
SURFACE WATER

|                    |      | <u>Minimum and Maximum Concentrations</u> |                                 |                      |
|--------------------|------|-------------------------------------------|---------------------------------|----------------------|
| <u>Constituent</u> |      | <u>Peat Deposit</u>                       | <u>Brucy Brook - Falls Lake</u> | <u>Suitcase Lake</u> |
| Uranium            | µg/L | 27 - 60                                   | <0.5 - 2.0                      | <0.5                 |
|                    |      | <u>Minimum and Maximum Activities</u>     |                                 |                      |
|                    |      | <u>Peat Deposit</u>                       | <u>Brucy Brook - Falls Lake</u> | <u>Suitcase Lake</u> |
| Th-230             | Bq/L | <0.005                                    | <0.005                          | <0.005               |
| Ra-226             | Bq/L | <0.005 - 0.017±0.004                      | <0.005 - 0.009±0.002            | <0.005               |
| Pb-210             | Bq/L | 0.36±0.08                                 | <0.3                            | -                    |
| Pa-210             | Bq/L | 0.35±0.03                                 | 2.8±0.2 - 5.4±0.5               | -                    |
| U-235              | Bq/L | 0.015±0.005                               | ---                             | -                    |
| Po-231             | Bq/L | <0.005                                    | <0.005                          | -                    |
| U-234/U-238        |      | 1.06±0.04 - 1.27±0.05                     | ---                             | -                    |



Relatively low levels of total alkalinity (4 to 15 mg/L as  $\text{CaCO}_3$ ), bicarbonate (5 to 17 mg/L as  $\text{HCO}_3$ ), hardness (3 to 21 mg/L as  $\text{CaCO}_3$ ), and total dissolved solids (14 to 70 mg/L) indicate that the surface water contains very little in the way of dissolved constituents and would be classified as "very soft".

As indicated in Table 12, all of the major ions were present in small amounts. The major cations are calcium and sodium and the major anions are bicarbonate and chloride, with little difference between samples regardless of origin. Similarly, the concentrations of the metals measured are low and showed little variation among samples. Iron, manganese and zinc showed the most variation but none of the values was exceptional, especially when the boggy nature of the study area is taken into account.

Surface water runoff from the peat deposit is similar in chemical composition to the groundwater as noted by the comparison of concentration ranges shown on Tables 9 and 12. Although much of the surface water runoff from the site is discharged groundwater, it is more dilute due to direct rainfall catchment.

The surface water in Brucy Brook and Falls Lake contains about one half the concentration of dissolved solids than does the runoff from the peat deposit indicating a higher component of groundwater baseflow in the latter. The alkalinity and hardness of the water draining from Suitcase Lake was some three times greater than that from Brucy Brook; probably due to the limestone underlying much of this drainage area. (see Table C-3, Appendix C).

Measured uranium concentrations and radium-226 activities (Table 13) can be used to divide the study area into two parts. The first contains surface water with relatively "high" values and occurs in the peat deposit area (Spring L28, Creek L28, and Creek L24 - see Figure 5 for locations). The second part includes the areas with "low" values (Brucy Brook, Falls Lake and Suitcase Lake). Within the peat deposit area, the measured uranium concentrations of 27 to 60 ug/L agree with previously reported values (Clark, 1978). Outside the deposit, uranium concentrations are 2 ug/L or less and are similar to background levels measured elsewhere across Canada (Langan, 1983). While differences were not as great for radium-226 activities, these values displayed the same pattern. The activities of uranium-235, thorium-230, lead-210 or protactinium-231 were low and were similar at the few stations where they were measured.

The concentrations of uranium in surface runoff from the peat deposit are similar to those of the groundwater discharge at the toe of the talus slope and in groundwater samples obtained from the till and bedrock beneath the peat (see Section 4.4.2). However, the surface water concentrations are of the order of ten times less than the groundwater concentrations within the peat (see Tables 7 and 13).

The ratio of uranium-234 to uranium-238 ranged from  $1.06 \pm 0.04$  to  $1.27 \pm 0.05$  in four samples. Again these ratios are consistent with those of the soil samples and groundwater (see Section 4.4).

The measured activities of lead-210 lie toward the upper end of the range reported in rain-water (Jaworoski, 1967). Reported activity ratio values of polonium-210 to lead-210 in

rain-water range from 0.1 to 0.54 (Parfenov, 1974) while the ratios observed in three samples from the study area indicate considerably more polonium-210, especially in Falls Lake. Recent studies indicate that biological, chemical and physical processes interact in a complex manner which subsequently determines the fate of the two radionuclides (Talbot and Andren, 1984). Aquatic biota, particularly plankton, appear to strongly influence removal of both from the water column. While this may be occurring in the study area, there is insufficient information on which to confidently base conclusions.

In summary, the waters of the study area were slightly acidic and very soft. Uranium concentrations and radium activities were higher (by factors of approximately 25 and 3, respectively) in surface waters that cross the deposit area. The migration of radionuclides by way of surface water flowing across the deposit appears to have minimal influence on the quality of Falls Lake, probably because flow from the deposit represents a small component of total flow into the lake. In addition, most surface water originating in the deposit must pass over organic material (which can adsorb various elements including radionuclides) before reaching the lake.

#### 4.5.2 Stream Sediments

Previous studies of stream and lake sediments within the study area focussed on the presence of uranium. Stream sediment concentrations ranged from 4.6 to 237 ppm uranium, with most values less than 50 ppm (Clarke, 1977). Lake sediment samples ranged from 3.2 to 730 ppm. Iron and manganese concentrations were also measured during these studies since many radionuclides are known to be strongly adsorbed by the hydrous oxides of these two elements and the

boggy nature of the study area suggests that such oxides should be abundant in local soils and sediments. Sediments rich in organic material also accumulate uranium. Organic-rich lake sediment has been collected in Newfoundland containing more than 1000 ppm of uranium (Davenport, 1980).

As noted in Section 2.5.2 sediment samples, were obtained at 20 stations within the study area (see Figure 5 for locations). The results of subsequent chemical and radiological analyses of these samples are given in Table C-4 of Appendix C and are summarized in Tables 14 and 15. As indicated in Table 14, the stream sediment samples showed little variation in major element chemistry between samples collected from the peat bog and Brucy Brook/Falls Lake. Of the various elements analyzed, iron and manganese levels were the highest. Values for both were in the middle of the reported ranges found in stream and lake sediment samples from the study area (Clarke, 1977). Concentrations of the other non-radioactive elements were generally low, typical of those found elsewhere, or otherwise unexceptional. Stream samples collected from the peat deposit and the organic silts on the bottom of Falls Lake tend to have a higher total kjeldahl nitrogen than the mineral sediment samples collected from Brucy Brook.

As with the surface water analysis program, the only sediment samples that demonstrated notable accumulations of uranium and radionuclides were those within the peat deposit (see Table 16). Samples taken from the peat deposit (Spring L28, Creek L28, Station #1 on Creek L24, and Big Rock Pond) which are largely fine peat muck, contained from 736 to 6460 ug/g (dry weight) of uranium, while mineral sediments from Brucy Brook and Falls Lake stations contained from 8 to 58 ug/g, and the Suitcase Lake sample had 6.4 ug/g of uranium. These

TABLE 14  
RANGES OF MAJOR ELEMENT CHEMISTRY  
STREAM SEDIMENT

| Constituent                | Minimum and Maximum Concentrations |                          |
|----------------------------|------------------------------------|--------------------------|
|                            | Peat Deposit                       | Brucy Brook - Falls Lake |
| TKN ppm as N               | 284 - 1420                         | 50 - 1250                |
| Total Sulphur ppm          | <75                                | <75                      |
| CaCO <sub>3</sub> Equiv. % | 0.2 - 1.1                          | 0.1 - 2.4                |
| Fe mg/L                    | 5.9 - 19.2                         | 8.0 - 14.1               |
| Cu ppm                     | 1.1 - 6.8                          | 2.6 - 6.5                |
| Mn ppm                     | 126 - 259                          | 86 - 198                 |
| Ni ppm                     | 13.9 - 31.5                        | 12.4 - 34.9              |
| Pb ppm                     | 15.8 - 43.3                        | 14.5 - 20.4              |
| Zn ppm                     | 1.9 - 8.8                          | 2.1 - 3.2                |
| As ppm                     | <1                                 | <1                       |

TABLE 15

RANGES OF URANIUM-THORIUM CONCENTRATIONS AND  
RADIONUCLIDE ACTIVITIES - STREAM SEDIMENT

| <u>Constituent</u> |      | <u>Minimum and Maximum Concentrations</u> |                                 |
|--------------------|------|-------------------------------------------|---------------------------------|
|                    |      | <u>Peat Deposit</u>                       | <u>Brucy Brook - Falls Lake</u> |
| Uranium            | ug/g | 55.6 - 3450                               | 6.4 - 57.8                      |
| Thorium            | ppm  | <1 - 5.7                                  | 3.0 - 10.2                      |
|                    |      | <u>Minimum and Maximum Activities</u>     |                                 |
| <u>Constituent</u> |      | <u>Peat Deposit</u>                       | <u>Brucy Brook - Falls Lake</u> |
| Th-230             | Bq/g | 0.095±0.019 - 4.21±0.12                   | 0.061±0.015 - 0.151±0.026       |
| Ra-226             | Bq/g | 0.193±0.026 - 3.39±0.10                   | 0.06±0.013 - 0.157±0.026        |
| Pb-210             | Bq/g | 1.11±0.09 - 5.50±0.25                     | 0.33±0.04                       |
| Pa-210             | Bq/g | -----                                     | -----                           |
| U-235              | Bq/g | -----                                     | -----                           |
| Po-231             | Bq/g | <0.005                                    | <0.005                          |
| U-234/U-238        |      | 0.84±0.05 - 1.35±0.05                     | -----                           |



values suggest that the peat deposit does not have a major influence on the sediment quality of Falls Lake or Brucy Brook. Further, the peat deposit area is a relatively small contributor to the sediment load that reaches Falls Lake.

#### 4.6 Biological Studies

##### 4.6.1 Vegetation

The study area lies within the Boreal forest of Northern Newfoundland (Area B29 of the Northern Peninsula Section as identified in Rowe, 1972). The area is characterized by medium quality coniferous forests (forest capability 5 to 6) dominated by balsam fir and black spruce. The major limiting factors to forest growth are the soil conditions and wetness. Conditions in the general area range from wet to dry and include peatland, rock barren and coniferous forest.

The part of the 1984 field program (see Section 2.6.1) a species inventory was prepared for both the site area and a control area at the end of Suitcase Lake (see Figure 6 for locations) and vegetation samples were collected for subsequent uranium and radionuclide analysis. The results of these analyses are presented in Appendix D.

The results of the species inventory, including the relative abundance of the observed species, for both the site area and the control area are summarized in Table 16. While the site area was not as well drained as the control area and contained a few more species, the vegetation at the two sites was generally similar and consisted predominantly of coniferous forest. However, heath type vegetation was found in open parts of the fringes of both areas. From this type of area, the lichen Cladina stellaris, the shrub Kalmia angustifolia and the epiphytic lichen Alectoria sarmentosa (growing on balsam fir) were also collected.

TABLE 16

COMMON PLANT SPECIES COMPRISING THE VEGETATION  
TYPE WITHIN THE CONTROL AND THE DEPOSIT AREAS

| Scale of Relative Abundance      |     |                          |                |                |
|----------------------------------|-----|--------------------------|----------------|----------------|
|                                  | r   | rare                     |                |                |
|                                  | +   | sparse                   |                |                |
|                                  | 1   | 5%                       |                |                |
|                                  | 2   | 25%                      |                |                |
|                                  | 3   | 25% - 50%                |                |                |
|                                  | 4   | 50% - 75%                |                |                |
|                                  | 5   | 75% - 100%               |                |                |
| <u>Scientific Name</u>           |     | <u>Common Name</u>       | <u>Control</u> | <u>Deposit</u> |
| (a) Trees                        |     |                          |                |                |
| <u>Abies balsamea</u>            | (s) | Balsam fir               | 4              | 3              |
| <u>Picea mariana</u>             | (s) | Black spruce             | 1              | 1              |
| <u>Picea glauca</u>              |     | White spruce             |                | +              |
| <u>Larix laricina</u>            |     | Larch                    | +              | +              |
| <u>Betula papyrifera</u>         | (s) | White birch              | 1              | 1 - 2          |
| (b) Shrubs                       |     |                          |                |                |
| <u>Sorbus decora</u>             |     | Showy Mountain Ash       | 1              | 1              |
| <u>Viburnum edule</u>            |     | Squashberry              | 1              | 1              |
| <u>Taxus canadensis</u>          |     | Canadian yew             |                | +              |
| <u>Cornus stolonifera</u>        |     | Red osier dogwood        |                | +              |
| (c) Herbs                        |     |                          |                |                |
| <u>Cornus canadensis</u>         | (s) | Bunchberry               | 2              | 2              |
| <u>Coptis groenlandica</u>       |     | Goldthread               |                | +              |
| <u>Linnaea borealis</u>          |     | Twinflower               | 1              | 1              |
| <u>Mitella nuda</u>              |     |                          |                | +              |
| <u>Dryopteris spinulosa</u>      | (s) | Woodfern                 | 2              |                |
| <u>Clintonia borealis</u>        |     | Yellow clintonia         | 1              |                |
| <u>Goodyera repens</u>           |     | Rattlesnake - plantation | +              |                |
| <u>Sanguisorba canadensis</u>    |     | Canadian burnet          | +              | 2              |
| <u>Calamagrostis inexpansa</u>   |     |                          |                | 2              |
| <u>Carex trisperma</u>           |     | Sedge                    |                | 2              |
| (d) Mosses                       |     |                          |                |                |
| <u>Hylocomium splendens</u>      | (s) |                          | 3              | 2              |
| <u>Pleurozium schreberi</u>      |     |                          | 2              | 2              |
| <u>Ptilium crista-castrensis</u> |     |                          | 2              | 2              |
| <u>Sphagnum capillaceum</u>      |     |                          |                | 4              |

Samples of species marked (s) were collected for chemical analysis.

As indicated in Appendix D, the results of chemical analyses of the balsam fir samples indicate that only the roots contained uranium at concentrations greater than the analytical detection limit of 0.1 ppm (dry weight). While few studies have been undertaken to evaluate the uptake of natural radionuclides by different plant groups (Sheard, 1985), these results are unexpectedly low considering similar data from other Canadian locations. For example, concentrations of up to 0.6 ug/g (1 ug/g = 1 ppm) have been measured in the twigs and leaves of black spruce and jack pine collected from a boreal forest region in northern Saskatchewan where local soils contained less than 20 ug/g of uranium (Sheard, 1985) and levels of 4 to 9 ug/g have been measured in the shoots and needles of pine trees grown in soils containing 26 ug/g of uranium (Sheppard and Thibault, 1980). However, a subsequent study (Sheppard and Thibault, 1984) measured less than 0.1 ug/g in black spruce twigs taken from a bog containing approximately 26 ug/g in the soil.

One possible explanation for the apparently low concentration of uranium in the balsam fir wood and bark samples may be the influence of local organic soils. Radionuclide uptake by plants has been observed to be depressed when peat soils are involved (Sheppard et al, 1981). Another explanation might be the presence in balsam fir of a blocking mechanism in the form of enzymes or root storage. This is thought to be the mechanism used by members of the pine family to minimize the uptake of heavy metals in areas underlain by serpentinized ultramafic rock in western Newfoundland (Roberts, 1980).

Two root samples of balsam fir from the area site were found to contain 137 and 29.3 ug/g of uranium. Again this is relatively low given the uranium concentrations measured in the deposit (Section 4.4.1). The results are also low

compared to the average value of 346 ug/g measured in the roots of pine tree seedlings grown in soil containing 26 ug/g of uranium (Sheppard and Thibault, 1980). The deposit data supports the possible explanation that peaty soil inhibits the uptake of uranium and other radionuclides.

The average results of the three composite samples of the other eight species of plants analyzed for uranium content are summarized in Table 17. Higher values were measured in the deposit samples for seven of the eight species.

The measured values (Table 17) are generally similar to those reported for other Canadian locations. Uranium concentrations in black spruce foliage have been reported at levels of 0.01 to 0.24 ug/g in parts of Saskatchewan where soils have uranium concentrations of 1 to 2 ug/g (Sheard, 1985). In the same parts of Saskatchewan, uranium concentrations in mosses ranged from 2.1 to 3.6 ug/g which is quite comparable to the 4.2 ug/g measured during the present study. Similar comparisons can be made between the shrubs and Cladonia stellaris collected in Saskatchewan with those from the present site. The observed concentrations in the moss and lichen lie towards the lower ends of reported concentration ranges for northern Ontario (Boileau et al, 1982). The pattern of decreasing uranium concentrations observed from moss to lichen to trees in the study area has also been observed in northern Saskatchewan (Sheard, 1985).

Other radionuclides were analyzed in fewer samples and only four samples were analyzed for all radionuclides (see Appendix D). These included two balsam fir root samples, the wood fern foliage and feather moss foliage collected at the peat deposit. As in the study area soils and sediments, the root samples demonstrated an uranium disequilibrium. The disequilibrium was less pronounced in the two foliage samples.

TABLE 17

TOTAL URANIUM IN FOLIAR PLANT TISSUE

|    | <u>Plant Species</u>          | <u>Plant Group</u>  | <u>Total Uranium (ppm)*</u> |                     |
|----|-------------------------------|---------------------|-----------------------------|---------------------|
|    |                               |                     | <u>Control</u>              | <u>Peat Deposit</u> |
| 1. | Black Spruce,<br>1984 foliage | Tree                | 0.1                         | 0.2                 |
| 2. | White Birch,<br>1984 foliage  | Tree                | 0.1                         | 0.8                 |
| 3. | <u>Kalmia angustifolia</u>    | Shrub               | 0.1                         | 0.1                 |
| 4. | <u>Cornus canadensis</u>      | Herb                | 0.1                         | 1.7                 |
| 5. | <u>Hylocomium splendens</u>   | Feather Moss        | 0.1                         | 3.7                 |
| 6. | <u>Dryopteris spinulosa</u>   | Wood Fern           | 0.1                         | 4.2                 |
| 7. | <u>Cladonia stellaris</u>     | Lichen              | 0.2                         | 1.2                 |
| 8. | <u>Alectoria Aarmentosa</u>   | Epiphytic<br>Lichen | 0.1                         | 0.3                 |

\* Average of three random composite samples.

The radium-226 activities measured in three foliage samples from the study area are slightly higher than those reported in the literature, while the concentrations in white birch and lichen samples from the control area are similar to those found at other locations (Sheard, 1985).

Little can be interpreted from the results of radionuclides except that the ratios of uranium-234 to uranium-238 are similar to those observed in the other parts of the study and that the lead-210 concentrations observed in the moss and fern foliage samples are similar to reported values for moss and lichen (Sheard, 1985).

#### 4.6.2 Aquatic Invertebrates

As noted in Section 2.6.2, it was decided that the scarcity of invertebrates at both the site area and control area would make it impractical to gather enough sample for chemical analysis. Consequently, the samples that were collected were used only for species identification. The results are given in Appendix D.

The specimens obtained from the control area stream (see Figure 6 for location) in the first day, one-hour Surber sample (Control Area Sample 1A), consisted of only eight families of invertebrates with only twelve individuals. The typical water beetle, midges, dragon and caddis flies were present in this sample. Three unknown larvae between life stages were encountered. Dragon flies had already hatched and only larvae cases were found. The second day one-hour Surber samples from the control stream (Control Area Sample 2A) yielded 24 individuals (ten families) with a few more individuals of the same families as the first sample plus a few parasitic worms.



The 8-hour Surber sample from the control stream (Control Area Sample 3A) yielded 15 families and 130 individuals and showed approximately eight times the average one-hour samples in terms of numbers. The most prevalent individuals (65 per cent) were the chironomidae or midge larvae. Other common species such as the mayflies, dragon flies, caddis flies as well as a few parasitic worms were the main invertebrates in the control stream.

In the outflow stream from Falls Lake, five one-hour Surber samples (Deposit Area Samples 1A, 1B, 2A, 3A and 3B) and two eight-hour Surber samples were taken (Deposit Area Samples 2B and 3C). Table 18 summarizes the results in terms of sample number, hours, number of families and total number of individuals.

Each of the samples showed consistent results in terms of both numbers of families and total individuals with very little difference between the control and deposit streams.

Chironomidae were the most common invertebrate found in the samples. They ranged from 8 to 65 per cent of the totals and, on average, made up more than one third of the total specimens collected. Mayflies and caddis flies accounted for a further 20 to 40 per cent of the total sample numbers.

The invertebrate specimens from both the control stream and the outlet from Falls Lake were identified by careful examination of their structural features. Neither stream site produced specimens with any physical malfunctions, unusual colour variations or abnormalities.

TABLE 18

SUMMARY OF AQUATIC INVERTEBRATES COLLECTED AT  
THE OUTFLOW FROM FALLS LAKE

| <u>Sample</u><br><u>No.</u> | <u>Period</u><br><u>(Hours)</u> | <u>Number of</u><br><u>Families</u> | <u>Total Number of</u><br><u>Individuals</u> |
|-----------------------------|---------------------------------|-------------------------------------|----------------------------------------------|
| Control Stream              |                                 |                                     |                                              |
| 1A                          | 1                               | 8                                   | 12                                           |
| 2A                          | 1                               | 10                                  | 24                                           |
| 3A                          | 8                               | 15                                  | 130                                          |
| Deposit Stream              |                                 |                                     |                                              |
| 1A                          | 1                               | 9                                   | 14                                           |
| 1B                          | 1                               | 8                                   | 21                                           |
| 2A                          | 1                               | 11                                  | 17                                           |
| 2B                          | 8                               | 16                                  | 122                                          |
| 3A                          | 1                               | 9                                   | 23                                           |
| 3B                          | 1                               | 13                                  | 37                                           |
| 3C                          | 8                               | 19                                  | 144                                          |

Invertebrate population levels in both the control stream and the deposit stream appear to be quite normal and correspond to the typically low population levels of common invertebrates found in lakes of glacial origin located on igneous bedrock. Similar results have been observed during studies of the Upper Salmon River and at Cat Arm (Airphoto Analysts and Beak Consultants, 1976).

#### 4.6.3 Fish

Due to the relatively low numbers of aquatic invertebrates in the study area, radionuclide data was obtained for fish specimens (Eastern Brook Trout) from both the Falls Lake outlet and the control site at the south end of Suitcase Lake (see Section 2.6.3). As indicated in Table 19, no major differences were detected in size, shape or form between the specimens of Eastern Brook Trout taken from the control stream at the south end of Suitcase Lake and those from the deposit stream outlet to Falls Lake. Slight weight differences were observed between and within both populations. This was most likely due to the amount of eggs carried by the female trout. No other fish species were caught or observed. The level of effort required to catch trout at each sampling site was roughly the same which indicates similar population densities. The flesh and bone sample for the fish from Falls Lake was found to contain 0.141 ug/g uranium (wet weight) while the control sample contained 0.069 ug/g. The average concentration of uranium in whole freshwater fish has been estimated to be in the range of 0.1 to 0.6 ug/g while dressed fish (flesh and bones) from nonindustrial areas of Manitoba have been reported to range from 1 to 3 ug of U per g of wet weight of fish (Langan, 1983). Eviscerated whole fish collected in northern Saskatchewan from background lakes (uranium concentrations of the order of 5 to 10 ug/g uranium)

TABLE 19

## CHARACTERISTICS OF EASTERN BROOK TROUT SPECIMENS

| Specimen<br>No. | Sex | Lgth<br>cm | Girth<br>cm | Wt<br>gm | Uranium*                                      |                                        | Sampling<br>Efforts<br>Rod-Hrs |
|-----------------|-----|------------|-------------|----------|-----------------------------------------------|----------------------------------------|--------------------------------|
|                 |     |            |             |          | Total<br>Flesh<br>and Bone<br>ppm<br>(wet wt) | Stomach<br>Contents<br>ppm<br>(wet wt) |                                |
|                 |     |            |             |          |                                               |                                        |                                |

---

|                              |   |      |      |    |       |       |              |
|------------------------------|---|------|------|----|-------|-------|--------------|
| Control Area (Suitcase Lake) |   |      |      |    |       |       |              |
| 1                            | F | 20.0 | 10.0 | 65 |       |       |              |
| 2                            | F | 18.5 | 9.0  | 53 |       |       |              |
| 3                            | F | 18.2 | 9.0  | 52 |       |       |              |
| 4                            | M | 16.5 | 8.0  | 41 |       |       |              |
| 5                            | M | 16.5 | 8.0  | 40 |       |       |              |
| 6                            | M | 13.0 | 7.0  | 23 | 0.069 | 0.013 | 0.75         |
| 7                            | M | 13.2 | 7.1  | 24 |       |       | (Equivalent  |
| 8                            | F | 11.0 | 5.0  | 15 |       |       | to 16        |
| 9                            | F | 11.5 | 5.2  | 16 |       |       | specimens    |
| 10                           | M | 10.0 | 4.9  | 14 |       |       | per rod hr.) |
| 11                           | M | 10.0 | 4.9  | 14 |       |       |              |
| 12                           | M | 10.0 | 4.9  | 14 |       |       |              |

|                           |   |      |      |    |       |       |              |
|---------------------------|---|------|------|----|-------|-------|--------------|
| Deposit Area (Falls Lake) |   |      |      |    |       |       |              |
| 1                         | F | 20.0 | 10.5 | 83 |       |       |              |
| 2                         | F | 19.0 | 11.0 | 82 |       |       |              |
| 3                         | F | 19.0 | 10.0 | 80 |       |       |              |
| 4                         | F | 18.5 | 9.5  | 65 |       |       |              |
| 5                         | M | 18.0 | 9.5  | 52 |       |       |              |
| 6                         | M | 18.0 | 9.5  | 52 | 0.141 | 0.128 | 1.0          |
| 7                         | M | 18.0 | 8.0  | 50 |       |       | (Equivalent  |
| 8                         | F | 15.0 | 8.5  | 43 |       |       | to 12        |
| 9                         | M | 13.0 | 6.5  | 25 |       |       | specimens    |
| 10                        | M | 12.0 | 5.5  | 19 |       |       | per rod hr.) |
| 11                        | M | 11.0 | 5.0  | 15 |       |       |              |
| 12                        | M | 10.0 | 4.9  | 14 |       |       |              |

\* Average of six specimens

have been found to contain less than 2 ug/g of uranium on an ash weight basis or approximately 0.05 ug/g on a wet weight basis (Swanson, 1983). Compared with published information, the two uranium levels measured during this study are unexceptional.

The stomach content sample for the fish from Falls Lake was found to contain 0.128 ug/g uranium (wet weight) while the control sample contained 0.013 ug/g uranium.

The results of the water quality program (Section 4.5.1) suggest that the uranium concentration in Falls Lake may be slightly higher than the concentration in Suitcase Lake. Further, the sediment sampling program (Section 4.5.2) indicates that the concentration of uranium in Falls Lake sediment is two or more times greater than the concentration in the sediment of Suitcase Lake. However the uranium bioaccumulation factors for the Falls Lake outlet and the control stream differ by a factor of 10 whether calculated on the basis of fish to water or fish to sediment.

Little can be derived from the few results of other radio-nuclides as most values were below the analytical limits of detection. The analysis of Falls Lake water indicate that the radium-226 content of the lake is less than 0.01 Bq/L. The bone and flesh measurement of 0.256 Bq/g (wet weight) of radium-226 in the Falls Lake fish sample can be used to calculate a bioaccumulation factor of as great as 25 L/g. Both the concentration and the bioaccumulation are greater than those reported in the literature. There is no apparent explanation for this anomolous value except that the concentration factor depends greatly on the amount of bone present in a sample. Similarly, there is no apparent explanation for the relatively high lead-210 concentration measured in the bone and flesh sample collected from the control sampling site.

#### 4.6.4 Microorganisms in Peat

As discussed in Section 2.6.4, peat samples from above and below the groundwater table were obtained in Test Pits 5, 8 and 10 to identify the predominant types and relative abundance of microorganisms occurring in the peat deposit. The results of the subsequent laboratory analyses are summarized in Table 20.

Several of the tests produced low numbers of bacterial colonies, thus eliminating certain types of microorganisms from further consideration. Low numbers of anaerobes were detected for all of the media. The absence of iron-oxidizing bacteria, for example, Thiobacillus ferrooxidans bacteria was indicated by the low numbers found on the SM medium.

The results of the TSA plates (Table 20) suggest that heterotrophic bacteria (those requiring organic compounds as a source of carbon) were present in all of the samples in significant numbers. This is not unexpected considering the high organic content of the peat. The single highest count of all the plates was the TSA plate for the shallow sample from Test Pit No. 5.

The results of the TM plates indicate that large numbers of bacteria that oxidize sulfur compounds (for example, Thiobacillus thioparus) were present in all samples and depths (see Table 20). The presence of these bacteria may explain the relatively high concentrations of sulphur encountered in the peat samples compared to the mineral soil (see Section 4.4.1). On the basis of colony morphology and the use of gram staining, it is suspected that several of the colonies on the TSA media may also have been facultative thiobacilli.



TABLE 20

RESULTS OF AEROBIC BACTERIA TESTS

| <u>Sample</u> | <u>TSA Count<sup>a</sup></u> | <u>TM Count<sup>b</sup></u> | <u>Samples<br/>Characteristics</u> |
|---------------|------------------------------|-----------------------------|------------------------------------|
| Test Pit 5    |                              |                             |                                    |
| - 15 cm       | $1.37 \times 10^6$           | $1.74 \times 10^5$          | 215 uR/hr, above<br>watertable     |
| - 60 cm       | $6.67 \times 10^5$           | $1.28 \times 10^6$          | 310 uR/hr, below<br>watertable     |
| Test Pit 8    |                              |                             |                                    |
| - 10 cm       | $3.20 \times 10^5$           | $7.78 \times 10^4$          | 50 uR/hr, above<br>watertable      |
| - 50 cm       | $1.22 \times 10^6$           | $3.63 \times 10^5$          | 120 uR/hr, below<br>watertable     |
| Test Pit 10   |                              |                             |                                    |
| - 20 cm       | $2.33 \times 10^5$           | $1.77 \times 10^4$          | 180 uR/hr, below<br>watertable     |
| - 1 m         | $3.80 \times 10^3$           | $1.47 \times 10^3$          | 350 uR/hr, below<br>watertable     |

Notes

- a - Colonies per gram of soil on trypticase soy agar.
- b - Colonies per gram of soil on thiobacillus medium with 0.5% thiosulphate (McCarthy and Charles, 1974).
- No colonies were found on Silverman's 9K medium (Silverman and Lundgren, 1959) and low, statistically unreliable numbers of colonies were found on Sabouraud dextrose agar.
- c - for location of test pits see Figure 4.

Only two fungus colonies were observed on the SDA medium. However, the plates were overgrown by a foul-smelling slimy mass. Gram staining revealed cells morphologically similar to those found on the TM, and these masses may also have been facultative thiobacilli.

Microbial activity is thought to be able to influence the movement of radionuclides via several mechanisms. These include changes in groundwater chemistry from oxidizing to reducing conditions brought about by anaerobic microbial activity. This could subsequently alter radionuclide speciation and solubility, also result in sorption of radionuclides onto mobile microorganisms. The formation of complexes between radionuclides and microbial residues such as humic substances may also occur. While the influence of microbial activity on a number of elements is well documented, relatively little information is available concerning radionuclide mobility (Loewen and Flett, 1984).

#### 5.0 AGE OF URANIUM MINERALIZATION

As discussed in Section 4.4.1, the uranium mineralization occurs predominantly within the post-glacial peat deposit which forms the surficial soil cover at the site. As such, the maximum age of the uranium mineralization is of the order of 15,000 years, the time since the glacial ice sheets finally retreated from the area. However, the age of the host peat deposit and hence the mineralization may be considerably younger than the maximum age since deglaciation, considering the comparatively thin accumulation of 0.5 to 1.75 m of peat present.

To obtain a better appreciation of the age of the mineralization (as opposed to the age of the peat deposit itself), the

residence time of the uranium within the peat was estimated from the relative measured uranium concentrations and thorium-230 activities in the peat. To this end, it was assumed that:

- o all of the uranium was originally dissolved in the groundwater or surface water and was precipitated or adsorbed within the peat. This is supported by the U-234 to U-238 ratios observed in the peat and water.
- o due to its low solubility, all of the thorium-230 within the deposit has accumulated in situ as a result of decay of uranium-238 (i.e. no thorium-230 was imparted by the groundwater or surface water), and
- o all of the thorium-230 produced within the deposit has remained in the deposit (i.e. no thorium-230 was transported off site by groundwater or surface water).

It was further assumed that within the peat deposit uranium-238 and uranium-234 are in equilibrium and, based on this assumption, that uranium-238 activities could be reasonably estimated from the measured total uranium concentrations. While this estimate of the uranium-238 activity could be adjusted according to the measured ratios of U-234 to U-238, based on the measured ratios the adjustment would be only about 10 per cent; an amount which is considered relatively unimportant given the level of uncertainty inherent in the assumptions. As indicated in the 'Notes' to Table 21, the age of the uranium mineralization within the deposit was estimated from the ratios of the measured thorium-230 activities and the calculated uranium-238 activities ('R' in Table 21) and the decay rate of uranium.

TABLE 21

AGE ESTIMATES OF THE URANIUM MINERALIZATION  
IN THE PEAT DEPOSIT

| Sample No.              | Type                            | Depth<br>Metres | Th-230<br>Bq/g | Uranium<br>ppm | U-238<br>Bq/g | Th-230/U-238<br>Ratio | Age<br>Years |
|-------------------------|---------------------------------|-----------------|----------------|----------------|---------------|-----------------------|--------------|
| TP5-SA1                 | Peat                            | 0-0.1           | 1.69±0.06      | 5320           | 64.90         | 0.026                 | 3000         |
| SA4                     | Peat                            | 0.3-0.4         | 6.20±0.11      | 17700          | 215.94        | 0.029                 | 3400         |
| SA7                     | Peat                            | 0.6-0.7         | 6.13±0.11      | 16500          | 201.30        | 0.030                 | 3500         |
| SA8                     | Silt                            | 0.7-0.9         | 1.34±0.05      | 1490           | 18.18         | 0.074                 | 3900         |
|                         | Sand                            | 0.7-0.9         | 0.24±0.03      | 246            | 3.00          | 0.080                 | 9600         |
| TP8-SA1                 | Peat                            | 0-0.1           | 0.084±0.012    | 255            | 3.11          | 0.027                 | 3200         |
| SA4                     | Peat                            | 0.3-0.45        | 2.61±0.06      | 22800          | 278.16        | 0.009                 | 1000         |
| TP10-SA1                | Peat                            | 0-0.2           | 11.1±0.2       | 2980           | 36.36         | 0.305                 | 42000        |
| SA4                     | Peat                            | 0.6-0.8         | 2.44±0.06      | 21200          | 258.64        | 0.009                 | 1000         |
| SA7                     | Peat                            | 1.2-1.4         | 9.82±0.14      | 27800          | 339.16        | 0.029                 | 3400         |
| Creek L24<br>Station #1 | Peat                            | 0-.05           | 4.21±0.12      | 6460           | 78.31         | 0.053                 | 6300         |
| Big Rock Pond           | Peat                            | 0-.05           | 1.22±0.073     | 3140           | 38.31         | 0.032                 | 3800         |
| Spring L28              | Peat and<br>Mineral<br>Detritus | 0-.05           | 0.7±0.049      | 736            | 8.98          | 0.078                 | 9400         |
| Creek L24<br>Station #2 | Peat and<br>Mineral<br>Detritus | 0-.05           | 0.095±0.019    | 55.6           | 0.68          | 0.140                 | 17400        |

Notes:

Conversion from uranium concentration to uranium-238 concentration accomplished using the relationship.

$$\mu\text{g/g of U} \times 0.0122 = \text{Bq/g of U-238}$$

Age T (in years) estimated according to the formula

$$R = \frac{\text{Th-230}}{\text{U-238}} \text{ ratio} = 1 - e^{(-8.66 \times 10^{-6} \times T)}$$

$$\text{or } T = \ln(1-R) / 8.66 \times 10^{-6}$$

For sample locations see Figure 4 and 5 and the Record of Test Pits in Appendix A.

The samples used for age determination included peat from various depths below ground surface in Test Pits 5, 8 and 10 and in one sample of the silt and sand underlying the peat in Test Pit 8. Stream sediment samples were also used; two of the sediment samples were largely comprised of peat (Creek L24, Station #1 and Big Rock Pond) and two of the sediment samples were comprised of both peat and mineral detritus (Spring L28 and Creek L24, Station #2).

As indicated in Table 21, with the exception of one anomalous result (TP10 - SA 1) the estimated age of the uranium mineralization within the main peat deposit (i.e. the test pit samples) ranges from about 1000 years to 3500 years but is generally in the range of 3000 years to 3500 years. The one anomalous result (42000 years) is considered to represent the effects of natural contamination of the peat by mineral detritus. While total uranium concentrations tend to increase with increasing depth (see Record of Test Pits 5, 7, 8, 9 and 10 in Appendix A), the analyses of the test pit samples do not show a clear relationship between the age of the mineralization and depth within the peat. However, if the uranium is continually being accumulated throughout the peat, strong age differences with depth would not necessarily be expected.

The estimated age of the uranium mineralization within the organic sediments in Big Rock Pond and Creek L24 (3800 years and 6300 years, respectively) is somewhat greater than that in the main peat deposit. The estimated age of the uranium mineralization in the mineral soil (TP5 - SA 8) and stream detritus (Spring L28 and Creek L24, Station #2) is even greater; ranging from about 9000 years to 17000 years. It is difficult to interpret these latter results as the uranium contained in the samples may include both adsorbed uranium

from the surface water and naturally occurring uranium decay series within the soil minerals themselves.

The age estimates obtained for the uranium mineralization of this site are similar to the radiometric ages determined for uranium mineralization in organic soils in southern British Columbia (Levinson et al, 1984).

## 6.0 SUMMARY AND CONCLUSIONS

### 6.1 Deposit Description

The Portland Creek uranium mineralization occurs within a sphagnum peat bog located between Falls Lake and the granite talus pile which occurs at the base of the Long Range Mountains Escarpment. The peat bog underlies an area of approximately 1.9 ha and varies in thickness from about 0.25 m to 1.5 m. It is underlain by sand and gravel till and granite bedrock occurs at depths of 2 to 5 m below ground surface.

The peat bog occurs within a groundwater discharge zone where seepage emerges from a prominent line of springs located at the toe of the granite talus. Much of this seepage runs off as surface drainage to Falls Lake although groundwater continues to flow westward toward the lake through the sand and gravel till underlying the peat bog. The granite talus provides the recharge for the groundwater flow system and the ultimate discharge zone is Falls Lake.

The results of geochemical sampling indicate that the peat within the bog has uranium concentrations ranging from about 70 to 28000 ppm whereas the underlying mineral soils contain about 5 to 2150 ppm uranium. It is estimated that the total



amount of uranium contained within the peat deposit is approximately 14 tonnes. By contrast, the concentrations of thorium in the peat were low, ranging from about 4 to 440 ppm. Previous investigations by Eldorado Nuclear Limited determined that the granite bedrock and talus within the area had uranium concentrations of 10 to 90 ppm and similar concentrations of thorium, ranging from 50 to 160 ppm.

The uranium mineralization in the peat was found to occur in strong secular disequilibrium with the U-238 decay series. The activity of U-238 in peat was estimated to vary from 3 to 340 Bq/g whereas the activities of Th-230 and Ra-226 measured within the same suite of samples was 0.084 to 11.2 Bq/g and 0.475 to 14.9 Bq/g, respectively. The comparatively low levels of gamma radiation (2 to 10 times background) encountered over the deposit is attributed to this lack of uranium decay products.

The age of the uranium mineralization within the peat deposit was estimated based on the accumulation of Th-230 from the decay of U-238. The range in age varied from 1000 to 3500 years, but was generally of the order of 3000 years. The ages are not considered absolute as U-238 is likely being continually added to the deposit. However, the ages obtained for the mineralization are consistent with the accumulation of the peat bog in recent (post-glacial) time.

The results of chemical analyses of groundwater found beneath the site indicate that it is a very soft, mildly acidic, calcium-sodium bicarbonate water characteristic of granitic terrain and bog areas. The uranium concentrations within the groundwater varied from 0.03 to 0.7 mg/L, the highest concentrations occurring in groundwater derived from the peat. Thorium - 230 and radium - 226 activities were very low, 0.005 to 0.145 Bq/L and 0.006 to 0.190 Bq/L, respectively.

The chemistry of the surface water running off the deposit was quite similar to that of the groundwater as much of it was derived from the line of springs along the base of the talus slope. The water in Brucy Brook and Falls Lake contained approximately half the concentrations of total dissolved solids as the runoff water from the site. The concentrations of uranium in the runoff water varied from 0.027 to 0.065 mg/L. The activities of thorium 230 and radium 226 in the surface water were below the detection limit of 0.005 Bq/L.

The uranium mineralization within the peat deposit is considered to be the result of precipitation or adsorption of uranium from groundwater possibly caused by strongly reducing conditions created in the peat by heterotrophic bacteria. The precipitation of uranium from solution is supported by U-234 to U-238 ratios of greater than 1 within the peat samples.

The uranium mineralization may occur as an oxide mineral phase or as a result of adsorption on the organic material within the peat. The source of this uranium is considered to be the granitic talus which forms the groundwater recharge zone. The uranium would be leached from the broken surfaces of the talus rock by rainfall and snow melt and subsequently transported in the groundwater to be later precipitated within the peat. The comparatively insoluble thorium and other uranium and thorium decay products would be leached to a far lesser degree. It is considered that the precipitation of uranium within the peat bog is an ongoing process.

## 6.2 Environmental Distribution of Key Elements

Elements and substances in the environment are subjected to a number of competing processes such as dissolution, precipita-

tion, adsorption, absorption and physical transport. One way to study environmental behaviour and/or distribution is to calculate the ratios of the concentration of the element or substance in two media. The ratio of the concentration in sediment to that in water is referred to as the distribution coefficient. Ratios of the concentration of an element accumulated with benthos to the concentration of the element in the water or sediment are referred to as bioaccumulation factors.

The most widely researched radionuclides of interest to this study are uranium and radium-226. Most of the Canadian data comes from studies in and around uranium mines and tailings areas in Saskatchewan and Ontario.

#### 6.2.1 Uranium

Uranium concentrations measured within the deposit, in the surrounding area and from locations beyond the influence of the deposit are summarized in Table 22. As indicated in this table, the measured uranium concentrations in the deposit are about 100 to 1000 times average values found elsewhere in Canada. (It should also be noted, however, that similar or higher values have been encountered at some other Canadian locations).

At Falls Lake, sediment levels are about 20 to 50 times lower than at the deposit. Concentrations at Falls Lake are about one to ten times those in the nearby control (background) areas. The few bioaccumulation ratios that could be calculated were generally similar for the three areas and generally agree with the few available published values.

TABLE 22

URANIUM SUMMARY

|                                | <u>Deposit</u>         | <u>Falls Lake</u>   | <u>Control Area</u> | <u>Published Data</u>     |
|--------------------------------|------------------------|---------------------|---------------------|---------------------------|
| • creek or stream water (ug/L) | 45<br>(30 to 60)       | -                   | -                   |                           |
| • lake water (ug/L)            | -                      | <0.5 to 2           | <0.5                | 0.05<br>(0.001 to 170)    |
| • sediment (ug/g dry)          | 500<br>(55 to 6460)    | 25<br>(10 to 60)    | 6.4                 | 4.6<br>(0.1 to 733)       |
| • fish (dressed)<br>(ug/g wet) | -                      | 0.128               | 0.013               | <3,<br>often <0.5         |
| • shallow groundwater (ug/L)   | 300 to 700             | -                   | -                   | -<br><1<br>(0.1 to 13000) |
| • tree foliage (ug/g dry)      | 0.1 to 0.8             | -                   | <0.1                | 0.01 to 0.6               |
| • lichen/fern/herb (ug/g dry)  | 0.3 to 10              | -                   | <0.1                | 0.01 to 3.5               |
| • peat (ug/g dry)              | 70 - 28100             | -                   | <10                 | 0.8 to 1620               |
| • sediment/water (g/mL dry)    | 6000 to<br>120,000     | 10,000 to<br>50,000 | >10000              | 500 to 30000<br>(wet)     |
| • fish/water (g/mL wet)        | -                      | >100                | >30                 | 10 to 1000                |
| • vegetation/soil (g/g dry)    | $10^{-4}$ to $10^{-5}$ | -                   | $10^{-2}$           | $10^{-4}$ to $10^{-1}$    |

Notes

- Published data largely based on Sheard, 1985, Swanson and SENES, 1985 and Langan, 1983.
- Single values are approximate mean or "typical values"; others are ranges.

### 6.2.2 Radium-226

Radium-226 activities measured at the deposit, in the surrounding area and from locations beyond the influence of groundwater entering or leaving the deposit are summarized in Table 23. As indicated in this table, the measured activities are about 2 to 50 times typical values found elsewhere in Canada. Notably high are the activities in the sediment and soil at the deposit and in the fish from Falls Lake.

### 6.3 Comparison of the Deposit to Tailings Areas

As noted in Section 1.1, the deposit was selected for study because it is situated in an environment which was considered to be generally similar to those that occur at currently active and inactive uranium mining areas in Canada and because of the known existence of uranium mineralization within the deposit. The environmental similarities included climate, groundwater depth and movement, the types of underlying strata, and local vegetation.

Based on the results of this study, a comparison of selected chemical, radiological and physical characteristics of the Portland Creek deposit with those of the currently active Elliot Lake and northern Saskatchewan mining areas is summarized in Table 24. As indicated on Table 24, the most striking differences between the deposit and tailings areas concern their chemistry. The deposit has an average uranium concentration of approximately 5000 ug/g; about 100 times the concentrations found in uranium tailings. However, the less environmentally-mobile daughter products (e.g. thorium-230) are at levels which were lower than those commonly found in uranium tailings. These relatively low levels of daughter

TABLE 43

RADIUM-226 SUMMARY

|                                         | <u>Deposit</u>    | <u>Falls Lake</u> | <u>Control Area</u> | <u>Published Data</u>  |
|-----------------------------------------|-------------------|-------------------|---------------------|------------------------|
| • creek or stream water<br>(m Bq/L)     | 10<br>(6 to 14)   | -                 | -                   | <5                     |
| • lake water (m Bq/L)                   | -                 | 8<br>(<5 to 10)   | <5                  |                        |
| • sediment (m Bq/g dry)                 | 170 to<br>3400    | 50 to 183         | 113                 | 4 to 400               |
| • fish (dressed)<br>(m Bq/g)            | -                 | 256 ± 60          | <5                  |                        |
| • shallow groundwater<br>(m Bq/L)       | 30 to 100         | -                 | -                   | -<br><10<br>(3 to 400) |
| • deep groundwater<br>(m Bq/L)          | 7 to 20           | -                 | -                   | -                      |
| • tree foliage (m Bq/g dry)             | 230 to 550        | -                 | 11 ± 2              | 5 to 31                |
| • lichen/fern/herb/moss<br>(m Bq/g dry) | 200 to 1400       | -                 | <5                  | 1 to 10                |
| • peat (m Bq/g dry)                     | 400 to 15000      | -                 |                     | 30 to 300              |
| • sediment/water<br>(mL/g dry)          | 1700 to<br>340000 | 6000 to<br>25000  | >20,000             | 1000 to<br>50000 (wet) |
| • fish/water (mL/g wet)                 | -                 | ~32000            | 1                   | <200                   |

Notes

- Published data largely based on Sheard, 1985, Swanson and SENES, 1985 and Swanson, 1983.
- Single values are approximate mean or "typical values"; others are ranges.



TABLE 24

COMPARISON OF PEAT DEPOSIT WITH URANIUM TAILINGS

| <u>Parameter</u>                              | <u>Portland Creek<br/>Deposit</u> | <u>Elliot Lake<br/>Mining Area</u> | <u>Northern Saskatchewan<br/>Mining Area</u> |
|-----------------------------------------------|-----------------------------------|------------------------------------|----------------------------------------------|
| uranium ( $\mu\text{g/g}$ dry)                | 200 to 28000                      | 50 to 100                          | 5 to 150                                     |
| radium-226 ( $\text{Bq/g}$ dry)               | 1 to 15                           | 15 to 20                           |                                              |
| thorium-230 ( $\text{Bq/g}$ )                 | 1 to 11                           | 15 to 20                           |                                              |
| lead-210 ( $\text{Bq/g}$ )                    | 2 to 5                            | 15 to 20                           |                                              |
| moisture content (%)                          | 70 to 80                          | 5 to 10                            | 1 to 30                                      |
| organic content (%)                           | 10 to 20                          |                                    | 1 to 4                                       |
| depth to watertable                           | 0.1 to 0.4                        | 0.1 - 10                           |                                              |
| pH                                            | 5 to 7                            | 2 to 12                            | 6 to 8                                       |
| hydraulic conductivity<br>( $\text{cm/s}$ )   | $10^{-5}$ to $10^{-7}$            | $10^{-7}$ to $10^{-6}$             |                                              |
| Rn-222 in groundwater<br>( $\text{Bq/L}$ )    | 200 to 1000                       |                                    |                                              |
| $\gamma$ levels at 1 m<br>( $\mu\text{R/h}$ ) | 10 to 30                          | 50 to 500                          | -                                            |
| mean annual<br>precipitation (mm)             | 1040                              | >800                               | 350                                          |
| degree days<br>above $5^{\circ}\text{C}$      | 1024                              | 1642                               | 1111                                         |

products results in lower levels of gamma radiation at the Portland Creek deposit than are generally encountered on uranium tailings.

The above notwithstanding, the most significance difference between the Portland Creek deposit and a uranium tailings facility proper is that, in its present state, the deposit functions as a point of accumulation of radionuclides rather than as a source of radionuclides. As such, the deposit is more typical of a "swampy" receptor down gradient (either surface water or groundwater gradient) of a tailings facility than it is of the facility itself. As such receptors are fairly common in both the Elliot Lake and northern Saskatchewan mining areas, the processes of dissolution, transport and deposition between the talus pile (the source) and the peat deposit (the receptor) offer some insight into the long-term processes which could be anticipated at a uranium tailings facility.

#### 6.4 Application of Results

##### 6.4.1 Uranium Tailings Management

Measurements from the study area suggest that uranium and its daughter products can be effectively isolated from the surrounding environment by a layer of saturated peat. This condition has been reported at the Nordic tailings area in Elliot Lake where a layer of peat that underlies the tailings has acted as a barrier to radionuclide migration. The Portland Creek study of a natural peat deposit suggests that if water leaving a tailings area can be allowed to flow through a living peat deposit, radionuclide migration can be significantly reduced.

Based on the performance of the organic material observed at the deposit and reported in the literature, a desirable feature of long-term uranium tailings management may be the development of an organic layer or deposit in groundwater discharge areas downgradient from the tailings. Probably less practical but nevertheless possible could be the use of organic material as a tailings basin liner.

#### 6.4.2 Other Applications

A recent paper addressing radionuclide partitioning coefficients in soils and plants noted the paucity of distribution coefficient values for organic soil (Sheppard, 1985). Swamps and low-lying areas can constitute important pathways in the Canadian environment and data are needed for organic soil (bog). The data gathered during the present or future studies of the Portland Creek deposit could be beneficial in this regard.

The data gathered from the study area is also of general scientific interest. The data base for most radionuclides is relatively small and focusses on areas with economically recoverable uranium mineralization where the activities of the radionuclides tend to be high. In contrast, the study area results are more indicative of areas or locations with only slightly elevated radionuclide activities. The study area data could also be used to expand the understanding of disequilibrium of radionuclides in natural settings or serve as a point of comparison for other geologically recent deposits such as those identified in British Columbia (Culbert, 1979).

## REFERENCES

- Airphoto Analysis Associated Consultants Limited and Beak Consultants Limited, 1976. Upper Salmon/Cat Arm Preliminary Environmental Impact Assessment, Department of Environment, St. John's, Newfoundland, 220 p.
- Boileau, L.H.R., Beckett, P.J., Lavoie, P. and Richardson, D.H.S., 1982. "Lichens and Mosses as Monitors of Industrial Activity Associated with Uranium Mining in Northern Ontario, Canada." Environmental Pollution (Series B), Volume 4, pp. 69-84.
- Brunskill, G.J., R.H. Hesslein, S.E.M. Elliott and C. Burns Flett. 1980. Report to AECL for contract work entitled, "137 Cs and 226 Ra in fish, water, and sediment from Great Slave Lake, Louis Lake, Lake Winnipeg, and FEA Lakes". Dept. of Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba.
- Butler, G.A., 1980. "Radioactivity in the Canadian Environment" Report prepared for the National Research Council of Canada, NRCC.
- CBCL, 1984. "A study of Naturally Occurring, Radionuclide Bearing Deposits at Portland Creek, Newfoundland - Phase I Report".
- Clarke, P.J., 1977. "Exploration Report Project 101 U6 Claims, Portland Creek Project, Newfoundland". Report for Conwest Canadian Uranium Exploration Joint Venture.
- Clarke, P.J., 1978. "Exploration Report Project 101 U6 Claims, Portland Creek Project, Newfoundland". Report for Conwest Canadian Uranium Exploration Joint Venture.
- Culbert, R.R., 1979. "Uranium Equilibrium-Disequilibrium in the Natural Environment British Columbia". Statement of evidence presented to the B.C. Royal Commission of Inquiry into Uranium Mining.
- Culbert, R.R. and Leighton, D.G., 1978. "Uranium in Alkaline Waters - Okanagan Area, British Columbia." Canadian Mining and Metallurgical Bulletin, Volume 71, pp.103-110.

- Colasurdo, M., 1979. "1979 Diamond Drilling, Radiometry and Soil Sampling - Portland Creek Pond Area, Newfoundland". Report for Eldorado Nuclear Limited and Report for Conwest Canadian Uranium Exploration Joint Venture.
- Colasurdo, M., 1979. "1979 Diamond Drilling, Radiometry and Soil Sampling - Portland Creek Pond Area, Newfoundland". Report for Eldorado Nuclear Limited.
- Davenport, P.H., 1980. "An Assessment of the Nature, Regional Distribution and Consequences of Removal of Recent Age Soil Uranium Deposits."
- Demayo, A., Taylor, M.C. and Reeder, S.W., 1980. "Guidelines for Surface Water Quality". Volume 1, Inorganic Chemical Substances.-Lead". Inland Waters Directorate, Water Quality Branch, Environment Canada.
- Environment Canada, 1982. "Canadian Climate Normals". Volume 2- Temperature; Volume 3. Precipitation; Volume 4-Degree Days. Atmospheric Environment Service.
- GRANT, D.R.
- 1969a: Surficial Deposits, Geomorphic Features, and Late Quaternary History of the Terminus of the Northern Peninsula of Newfoundland and Adjacent Quebec-Labrador; Mar. Sed., v.5, p. 123-125.
- 1969b: Late Pleistocene Re-advance of Piedmont Glaciers in Western Newfoundland; Mar. Sed., v.5, p. 126-128.
- Jaworowski, Z., 1967. "Stable and Radioactive Lead in Environment and Human Body". Nuclear Information Center, Warsaw. Cited by M. Eisinger in Environmental Radioactivity, Second Edition, 1973. Academy Press.
- Langan, J.S. 1983. "Guidelines for Surface Water Quality. Volume 1, Inorganic Chemical Substances - Uranium". Inland Waters Directorate, Water Quality Branch, Environment Canada.
- Levinson, A.A., Bland, C.J., Dean, J.R., 1984. "Uranium series disequilibrium in Young Surficial Uranium Deposits in Southern British Columbia", Canadian Journal of Earth Sciences Vol. 21, pg 559-566.

- Lindsay, W.L., 1979. Chemical Equilibria in Soils. John Wiley and Sons, Inc., 449 pp.
- Loewen, N.R. and R.J. Flett, 1984. "The Possible Effects of Microorganisms Upon the Mobility of Radionuclides in the Groundwaters of the Precambrian Shield." Prepared for Atomic Energy of Canada Limited, AECL Report TR-217. (78 pages).
- McCarthy, J.T. and A.M. Charles, 1974. "CO fixation by the facultative autotroph *Thiobacillus novellus* during autotrophy-heterotrophy interconversions. Canadian Journal of Microbiology, volume 20, pp. 1577-1584.
- Parfenov, Y.D., 1974. "Polonium-210 in the Environment and in the Human Organism". Atomic Energy Review, Vol. 12, pp.75-143.
- Prichard, H.M. and Gesell, T.F., 1977. "Rapid Measurements of Radon-222 Concentrations in Water with a Commercial Liquid Scintillation Counter." Article in Health Physics, volume 33, p.577.
- Roberts, B.A., 1980. Concentrations of Micro-nutrients (trace elements) in native plants growing on Serpentine Soils from Western Newfoundland. Paper presented at the Botany 80 Symposium at the University of British Columbia, Vancouver, 12 - 16 July 1980. Abstr., Bot. Soc. Am. Misc. pub. 158, p. 95.
- Rowe, J.S., 1972, Forest Regions of Canada, Department of the Environment, Canadian Forestry Service, Pub. No. 1300, 172 p.
- Sheard, J.W., 1985. "A Preliminary Study of Radionuclide Distributions in the Upland Vegetation of Northern Saskatchewan". A joint project of the University of Saskatchewan and Saskatchewan Research Council, SRC Publication E-902-5-B-85.
- Sheppard, M.I., 1985. "Radionuclide Partitioning Coefficients in Soils and Plants and Their Correlation." Health Physics, Vol.49, pp. 106-111.
- Sheppard, M.I., Reid, J.A.K., Thibault, D.H., Chen, J.D. and Vandergraaf, T.T., 1981. "Technetium Uptake by and Yield of Swiss Chard Grown on Peat and Sand". Atomic Energy of Canada Limited Report AECL-7275.



- Sheppard, M.I. and Thibault, D.H., 1984. "Natural Uranium Concentrations of Native Plants Over a Low-grade Ore Body". Canadian Journal of Botany, Volume 62, pp. 1069-1075.
- Sheppard, M.I. and Thibault, D.H., 1980. "Uptake of Uranium Thorium and Arsenic from Refinery Residue by Pinus Sylvestris L. and the Effect on Growth". Atomic Energy of Canada Limited Report AECL-7397.
- Silverman, M.D. and D.G. Lundgren, 1959. "Studies of the chemoautotrophic iron bacterium Ferrobacillus ferrooxidans - An improved medium and a harvesting procedure for securing high cell yields". Journal of Bacteriology, volume 77, pp. 642-647.
- Swanson, S. and Abouguendia, Z., 1981. "The Problem of Abandoned Uranium Tailings in Northern Saskatchewan-An Overview". Saskatchewan Research Council Publication No. C-805-48- C-81.
- Swanson, S.M. and SENES Consultants Limited, 1985. "A study of Naturally Occurring Radionuclides in Freshwater Benthos and Their Environment - Phase II Report, Field Program". Prepared for the National Uranium Tailings Program.
- Swanson, S.M., 1983. "Levels of Ra-226, Pb-210 and Total U in Fish near a Saskatchewan Uranium Mine and Mill". Health Physics, Volume 45, pp.67-80.
- Talbot, R.W. and Andren, A.W., 1984. "Atmospheric Fluxes and Geochemistries of Stable Pb, Pb-210 and Po-210 in Crystal Lake, Wisconsin". U.S. Environmental Protection Agency Report EPA-600/53-84-022.
- U.S. Environmental Protection Agency, 1977. "Radiological Quality of the Environment in the United States, 1977. Prepared by the EPA Office & Radiation Protection.

# LOCATION MAP PORTLAND CREEK NEWFOUNDLAND

FIGURE 1



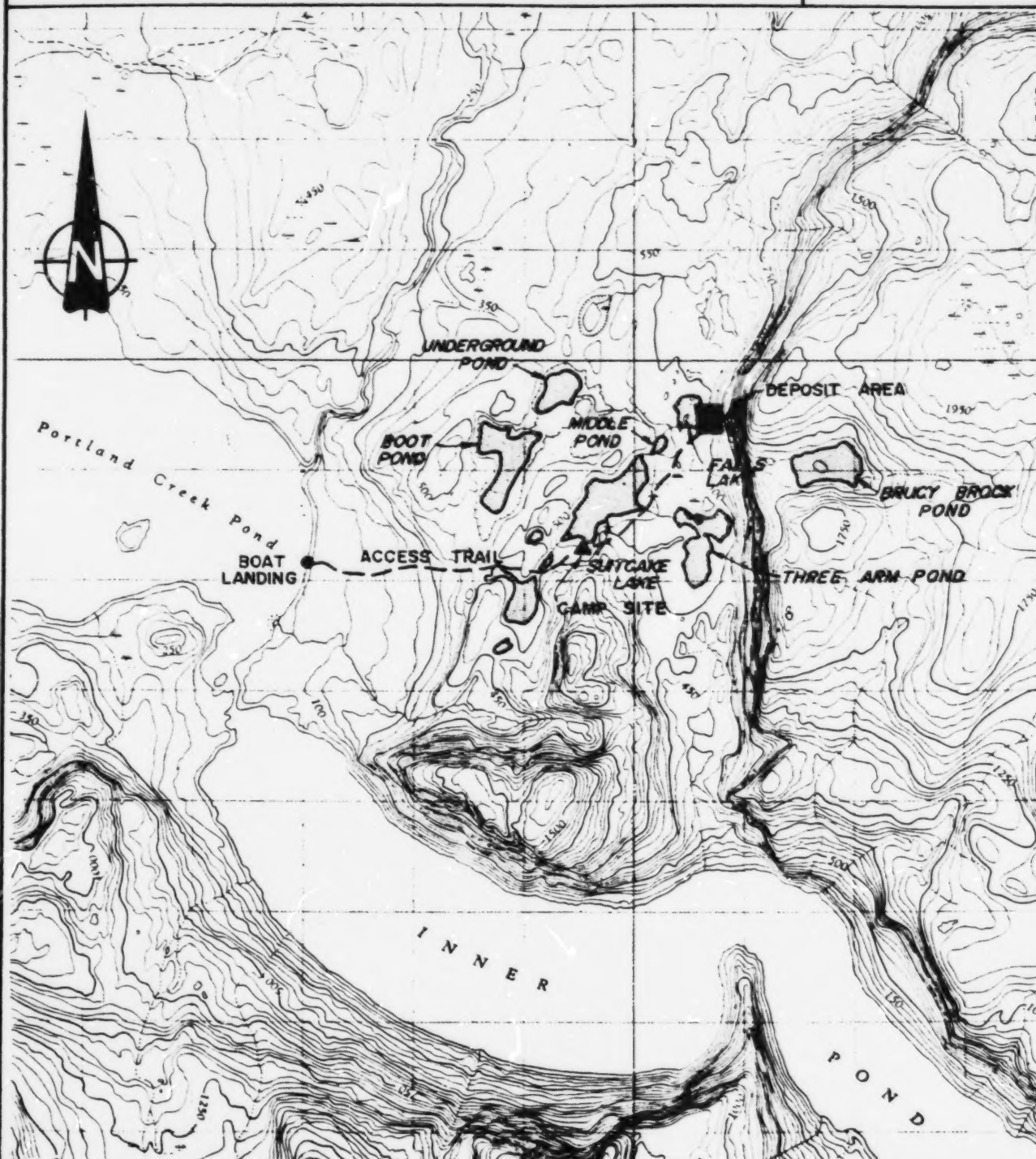
Date JULY 3, 1985  
Project No. 841-5033

Golder Associates

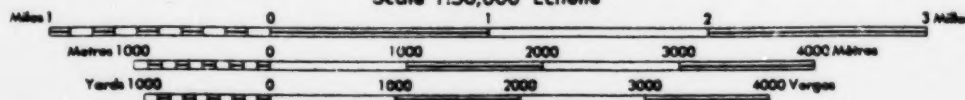
Drawn D.M.  
Chkd R.D.B.

# SITE ACCESS , CAMP AND DEPOSIT LOCATION PORTLAND CREEK , NEWFOUNDLAND

FIGURE 2



Scale 1:50,000 Échelle



Date JULY 31-1985  
Project No. 84J-5033

Golder Associates

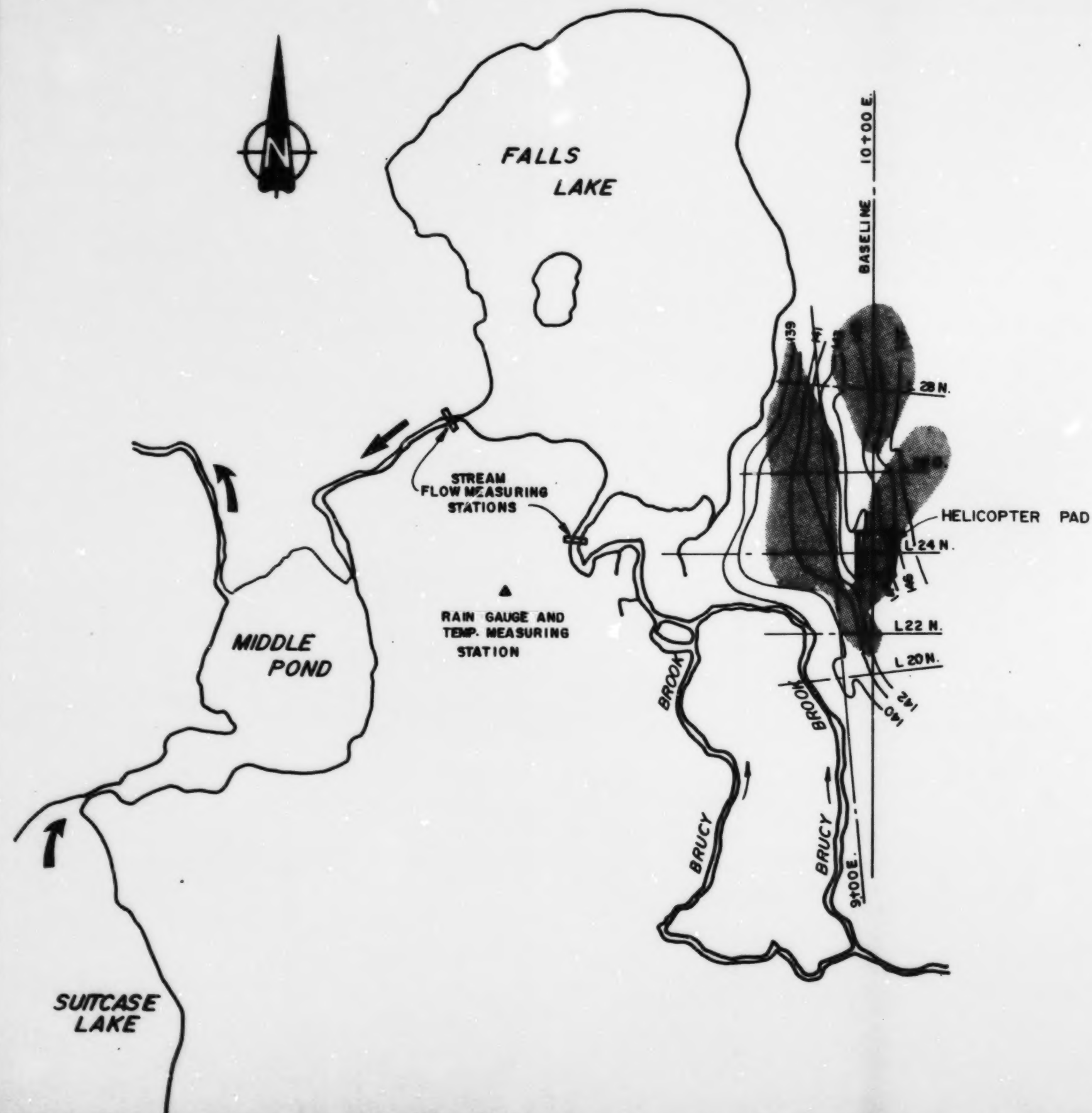
Drawn L.L.  
Chkd. R.D.B.





SITE PLAN INCLUDING SURVEY  
GRID AND ELEVATION CONTOURS  
PORTLAND CREEK, NEWFOUNDLAND

FIGURE 3



LEGEND

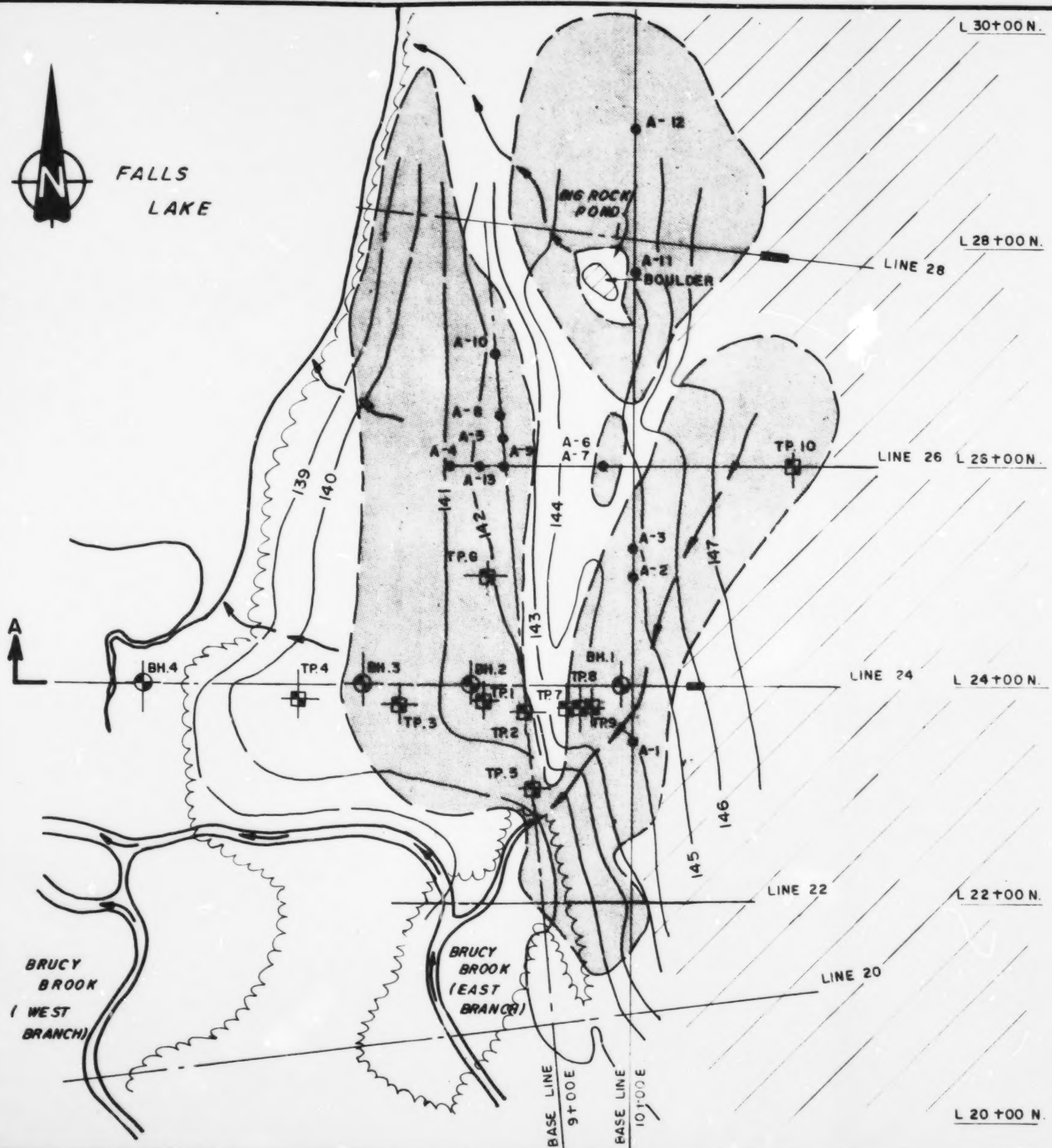
-  URANIFEROUS SPHAGNUM PEAT BOG
-  PICKET LINE, CHAINAGES IN FEET BASED ON PREEXISTING EXPLORATION GRID
-  139 CONTOUR ELEVATIONS IN 1m. INTERVALS BASED ON SITE DATUM, APPROXIMATE ONLY

SCALE 0 25 50 100 200 METRES

Date... JULY 3, 1985  
Project... 841-5033

Golder Associates

Drawn... D.M.  
Chkd... R.P.B.



# SUBSURFACE INVESTIGATION PLAN PORTLAND CREEK, NEWFOUNDLAND

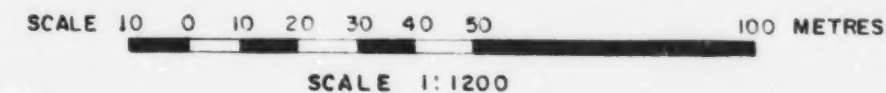
FIGURE 4

## LEGEND

-  URANIFEROUS SPHAGNUM PEAT BOG
-  GRANITE TALUS SLOPE
-  EDGE OF FORESTED AREA
-  DIRECTION OF SURFACE WATER FLOW
-  BOREHOLE LOCATION IN PLAN
-  TEST PIT LOCATION IN PLAN
-  AUGER PROBE LOCATIONS WITH CHEMICAL ANALYSES
-  EXPLORATION TRENCH FROM PREVIOUS INVESTIGATIONS
-  CUT PICKET LINE
-  140 ELEVATION CONTOURS IN 1 METRE INTERVALS

## NOTES

- 1) PICKET LINE CHAINAGES IN FEET BASED ON PREEXISTING EXPLORATION GRID.
- 2) ELEVATIONS BASED ON SITE DATUM, APPROXIMATE ONLY.
- 3) FOR SECTION A-A REFER TO FIGURE 10



L 20+00 N.

Date: MAR. 29, 1985  
Project: 841-5033

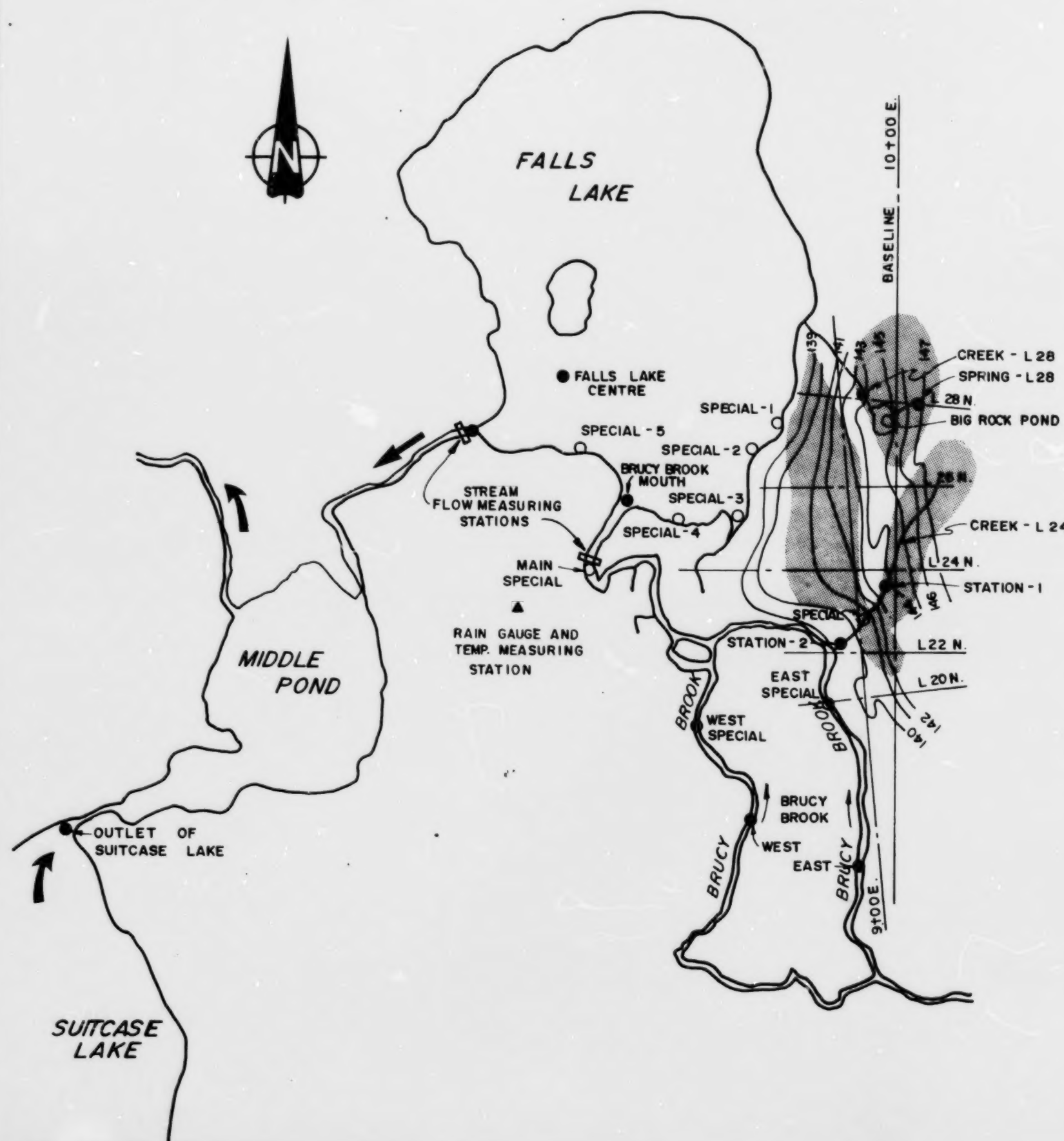
Golder Associates

Drawn: D.M.  
Chkd: R.D.B.

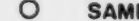


**SURFACE WATER AND STREAM  
SEDIMENT SAMPLE LOCATIONS  
PORTLAND CREEK, NEWFOUNDLAND**

**FIGURE 5**



**LEGEND**

-  URANIFEROUS SPHAGNUM PEAT BOG
-  PICKET LINE, CHAINAGES IN FEET BASED ON PREEXISTING EXPLORATION GRID
-  139 CONTOUR ELEVATIONS IN 1m INTERVALS BASED ON SITE DATUM, APPROXIMATELY ONLY
-  SAMPLE STATION WITH BOTH SURFACE WATER AND STREAM SEDIMENT SAMPLES
-  SAMPLE STATION WITH STREAM SEDIMENT SAMPLE ONLY

SCALE 0 25 50 100 200 METRES

Date... JULY 3, 1985  
Project... 041-5033

**Golder Associates**

Drawn... D.M.  
Chkd... R.D.B.



BIOLOGY SAMPLING LOCATIONS  
PORTLAND CREEK, NEWFOUNDLAND

FIGURE 6



Scale 1:50,000 Échelle



Date JULY 31-1985  
Project No. B41-5033

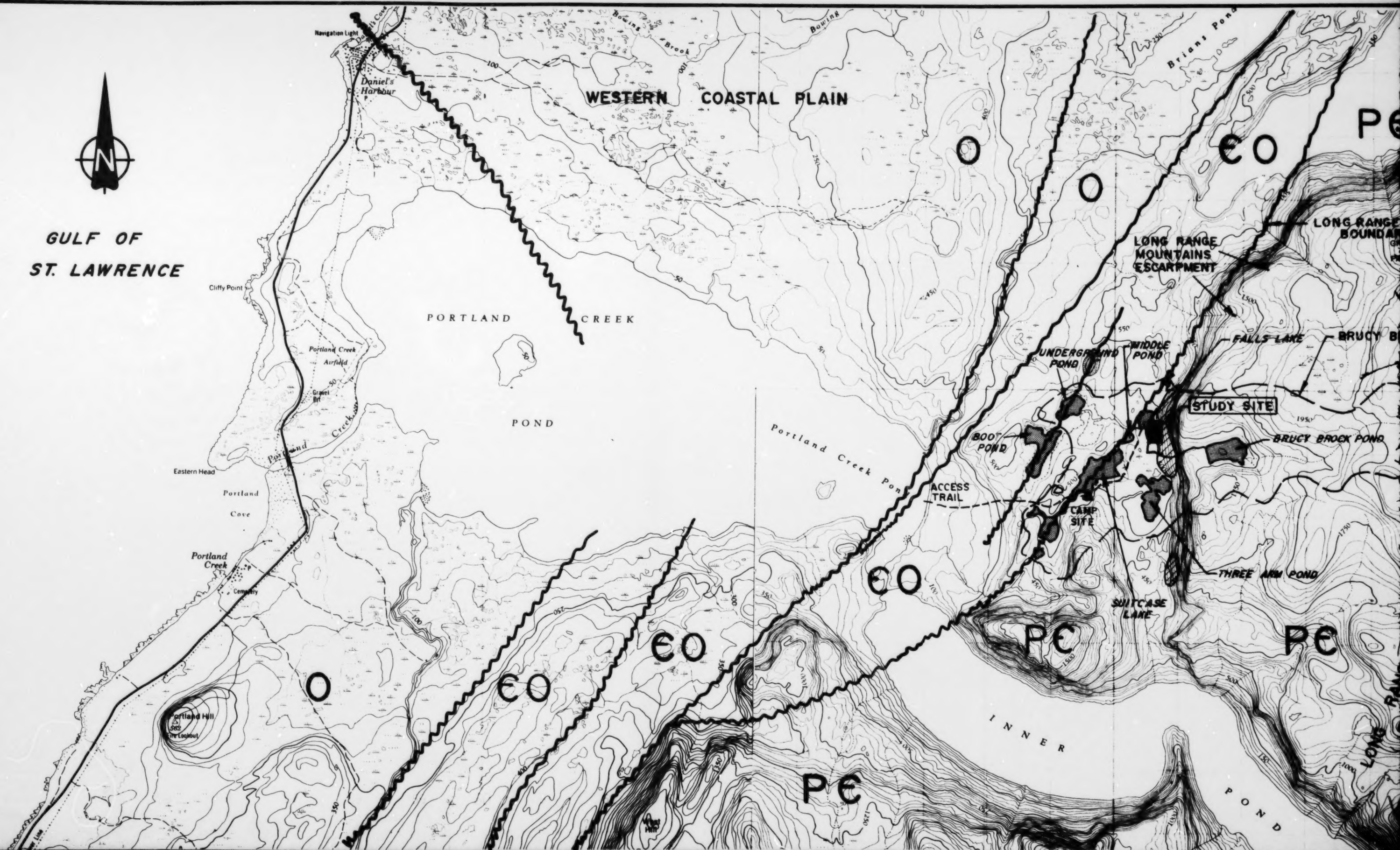
Golder Associates

Drawn LL  
Chkd. RBA





GULF OF  
ST. LAWRENCE





# REGIONAL PHYSIOGRAPHY, GEOLOGY AND DRAINAGE PORTLAND CREEK NEWFOUNDLAND

FIGURE 7

## LEGEND

- O ORDOVICIAN - DARK GREY TO BLACK LIMESTONE, SOME DARK CALCAREOUS SHALE AND GREYWACKE
- EO CAMBRIAN TO ORDOVICIAN - DARK GREY LIMESTONE AND DOLOSTONE
- PE LATE PRECAMBRIAN - PINK MASSIVE QUARTZ MOTIZONITE GRANODIORITE AND GRANITE.

## SYMBOLS

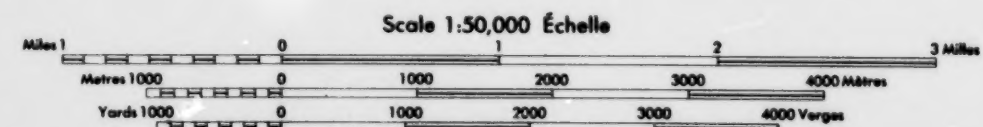
- FAULT
- TALUS

## REFERENCE

GEOLOGY INTERPRETED FROM MAP 82-53, GEOLOGY PORT SANDERS, COMPILED BY W.R. SMYTH, MINERAL DEVELOPMENT DIVISION, DEPARTMENT OF MINES AND ENERGY, GOVERNMENT OF NEWFOUNDLAND AND LABRADOR.

BASE MAP COMPILED FROM PORTIONS OF NATIONAL TOPOGRAPHIC SURVEY MAPS 12-1/3 AND 12-1/4

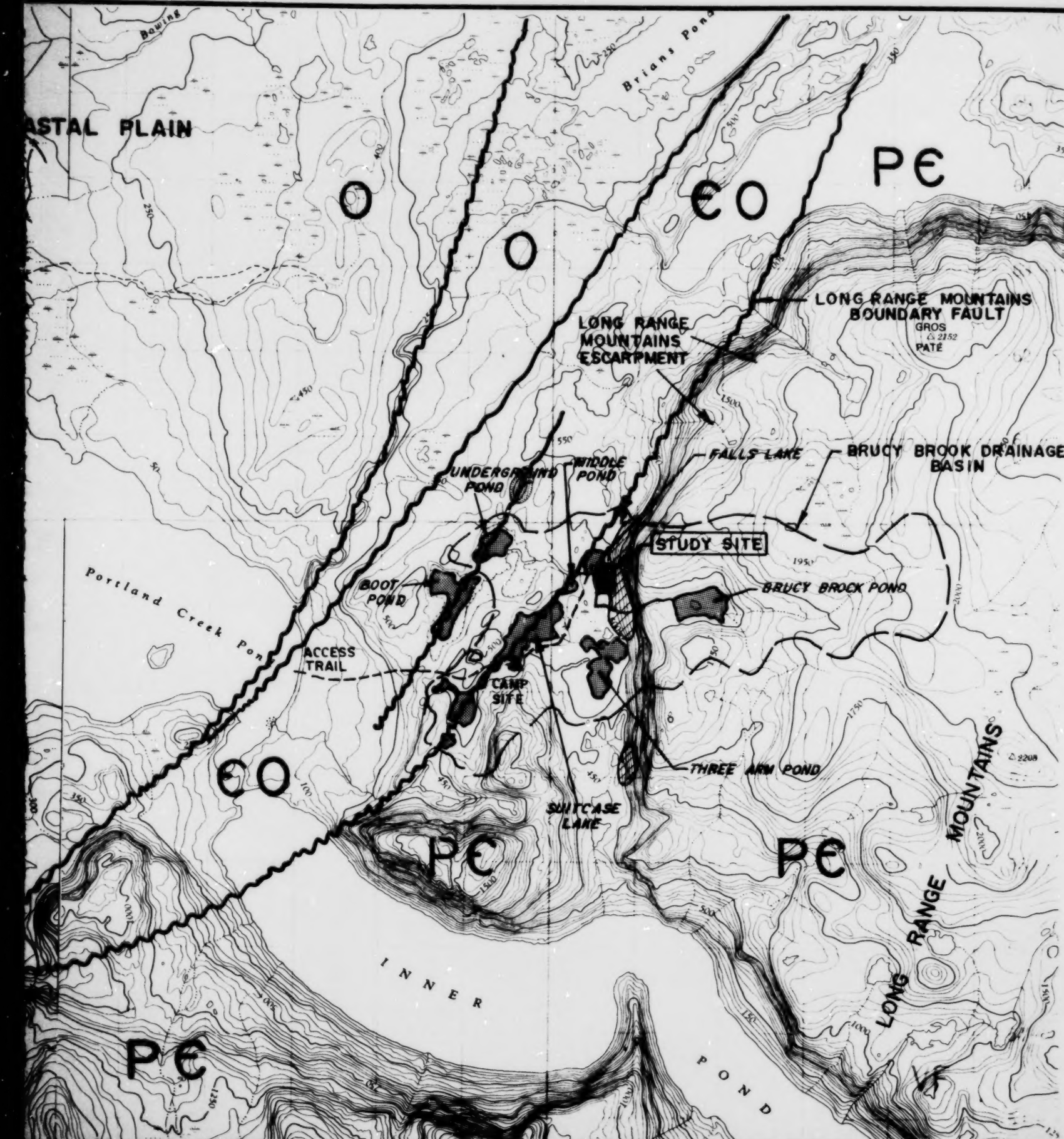
CONTOUR INTERVAL 50 FEET  
Elevations in Feet above Mean Sea Level  
North American Datum 1927  
Transverse Mercator Projection



Date... APRIL 3, 1985  
Project... 841-5033

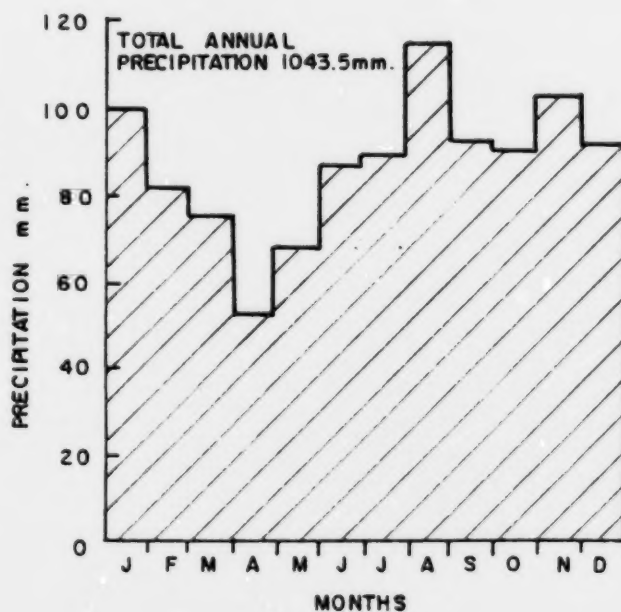
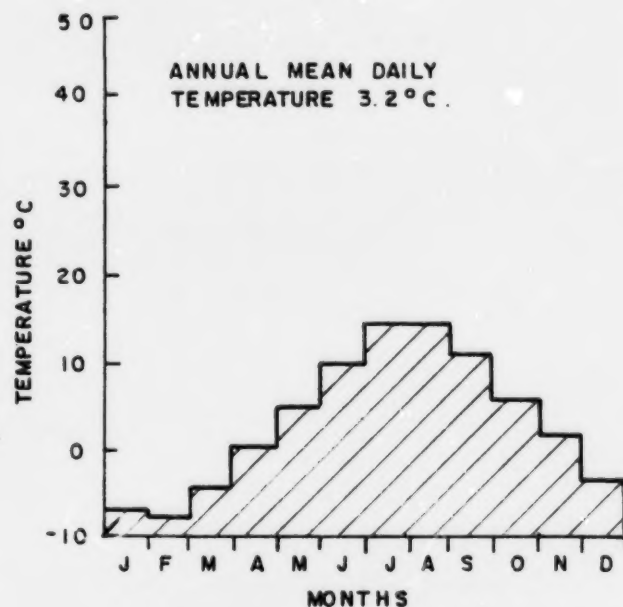
Golder Associates

Drawn... D.M.  
Chkd... R.D.B.



MEAN MONTHLY TEMPERATURE AND TOTAL  
MONTHLY PRECIPITATION, 1951 TO 1980  
DANIELS HARBOUR, NEWFOUNDLAND

FIGURE 8



NOTE: DATA FROM CANADIAN CLIMATE CENTRE, ATMOSPHERIC  
ENVIRONMENT SERVICE, ENVIRONMENT CANADA.

Date APRIL 8, 1985  
Project No. 841-5033

**Golder Associates**

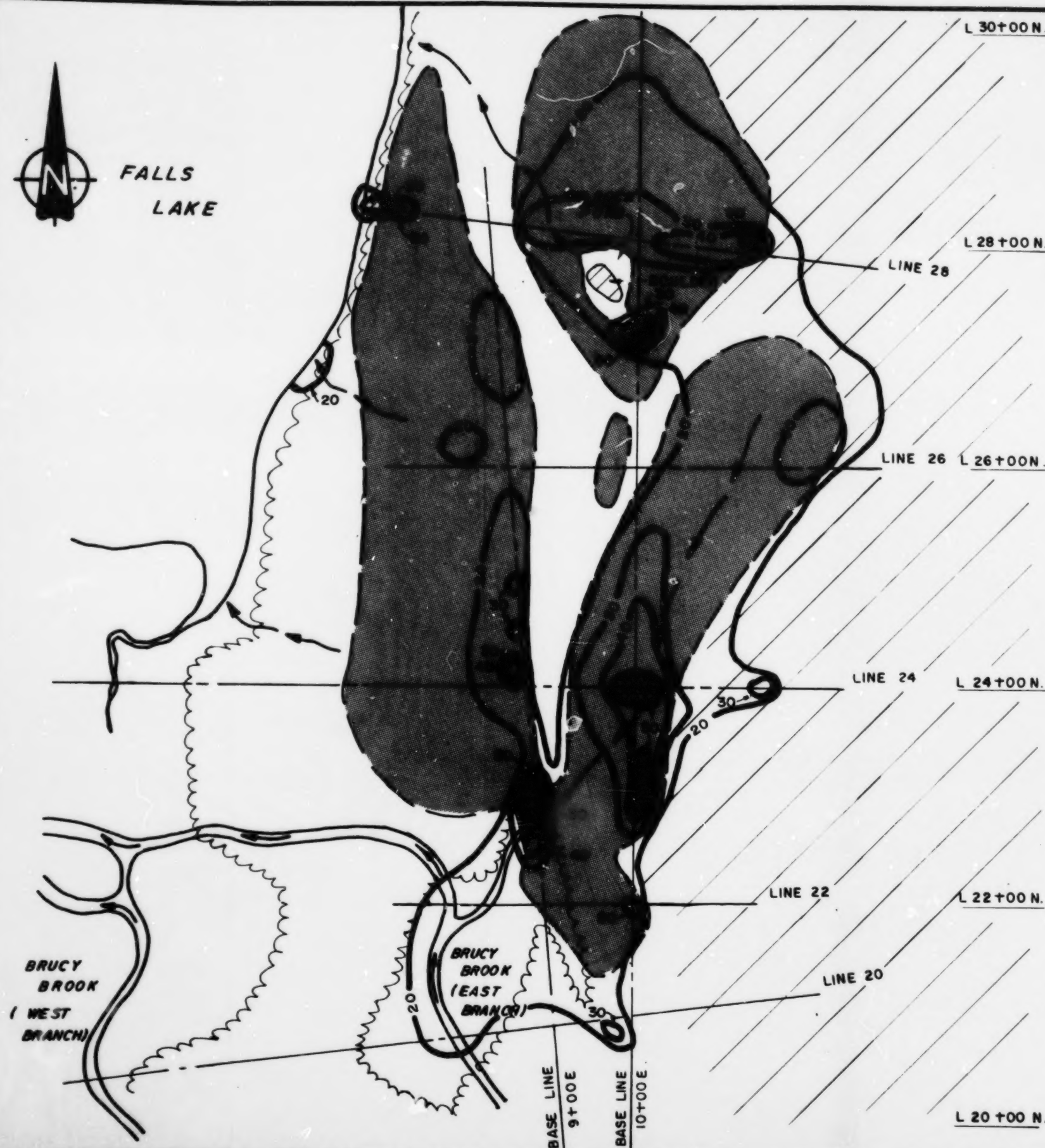
Drawn D.M.  
Chkd. -----





# GAMMA RADIATION SURVEY PORTLAND CREEK, NEWFOUNDLAND

FIGURE 9



## LEGEND

-  URANIFEROUS SPHAGNUM PEAT BOG
-  GRANITE TALUS SLOPE
-  EDGE OF FORESTED AREA
-  DIRECTION OF SURFACE WATER FLOW
-  CUT PICKET LINE
-  EXPLORATION TRENCH FROM PREVIOUS INVESTIGATIONS
-  20 — GAMMA RADIATION CONTOUR  $\mu\text{R/hr}$  (CONTOURS IN 10  $\mu\text{R/hr}$  INTERVALS)
-   $\geq 50 \mu\text{R/hr}$  (MAX. 120  $\mu\text{R/hr}$ )

## NOTES

PICKET LINE CHAINAGES IN FEET BASED ON PREEXISTING EXPLORATION GRID.

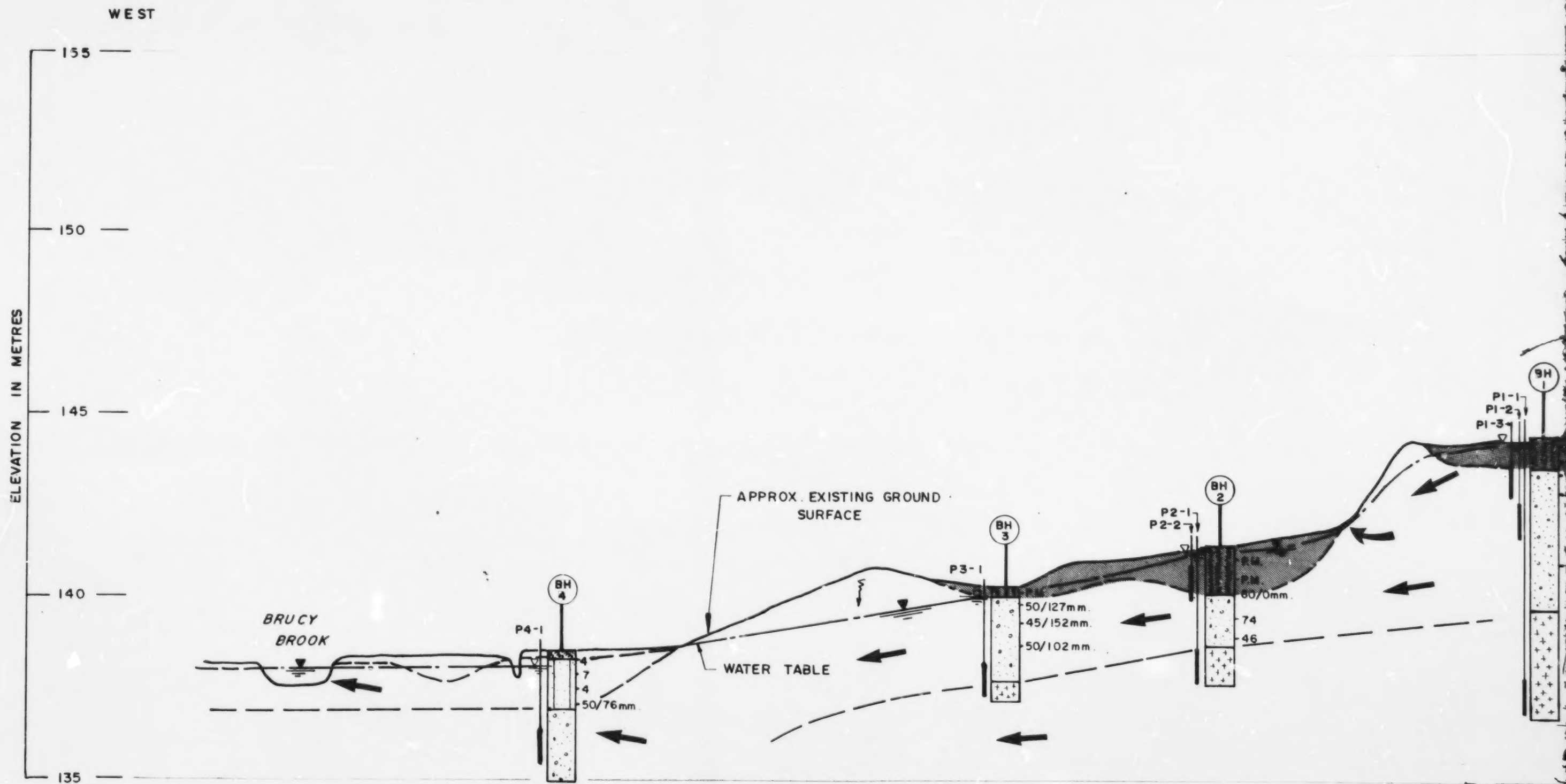
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SCALE 1:1200

L 20+00 N.

Date... MAR. 29, 1985  
Project... 841-5033

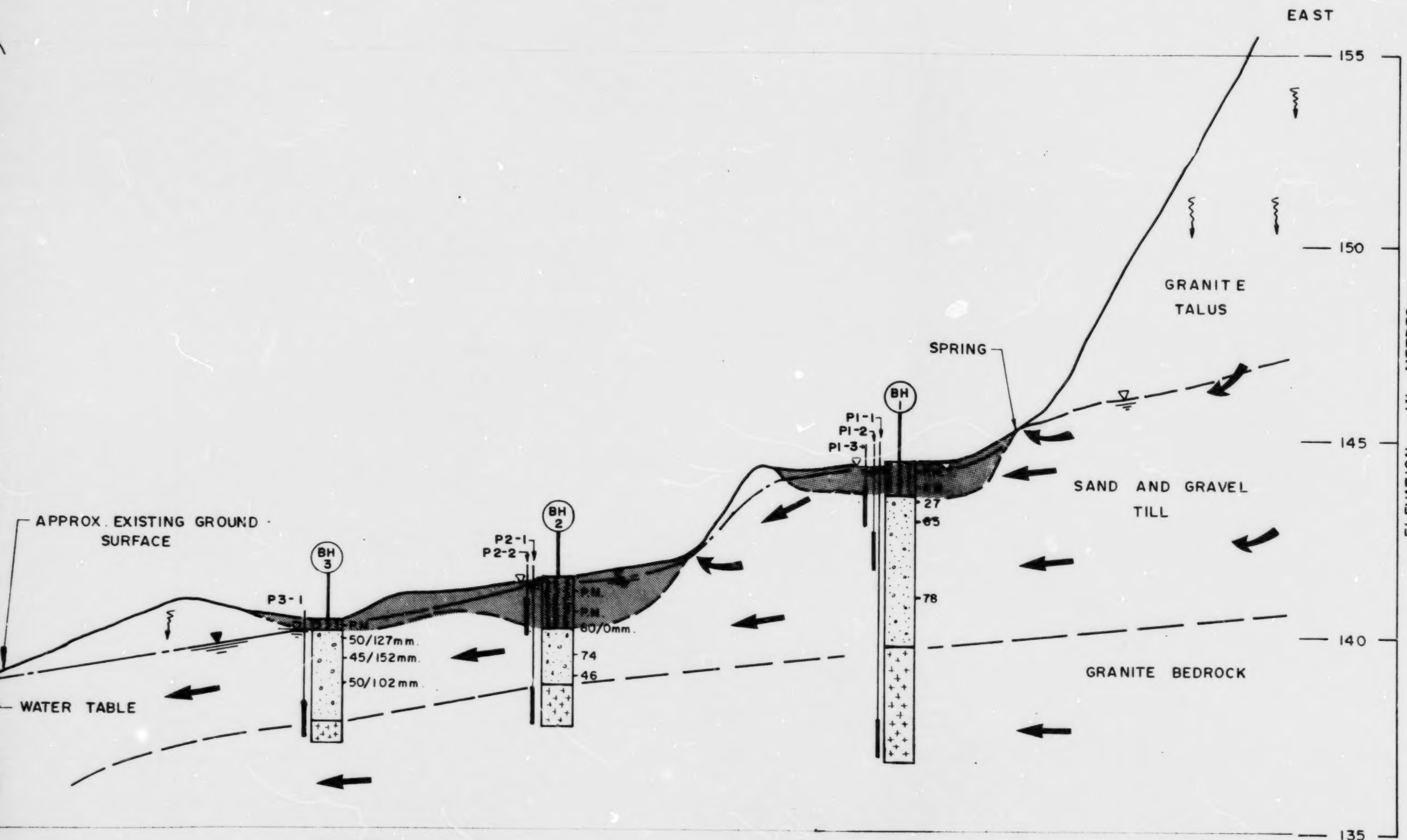
Golder Associates

Drawn... D.M.  
Chkd... R.D.B.



SECTION A-A  
LINE 24+00 N.

SECTION A-A, STRATIGRAPHY  
AND GROUNDWATER CONDITIONS  
PORTLAND CREEK, NEWFOUNDRAND



SECTION A-A  
LINE 24+00 N.

Date: APRIL 2, 1985  
Project: 841 - 5033

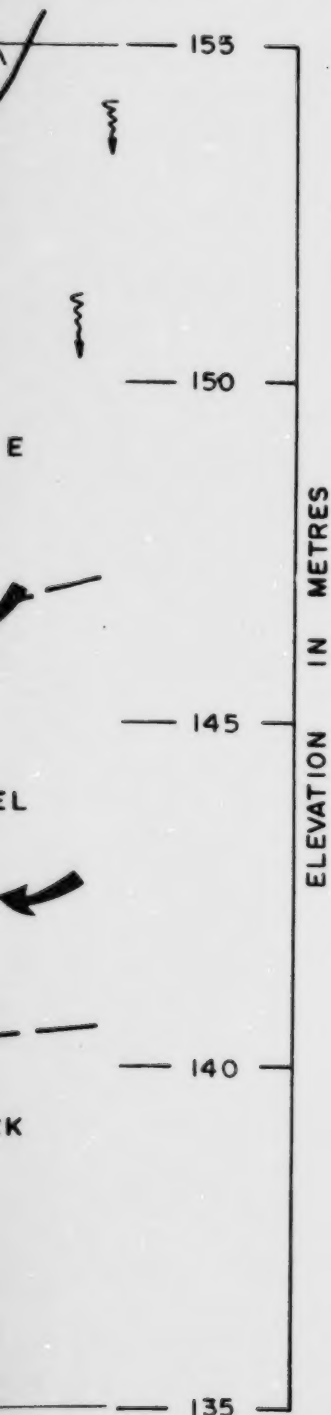
Golder Asso



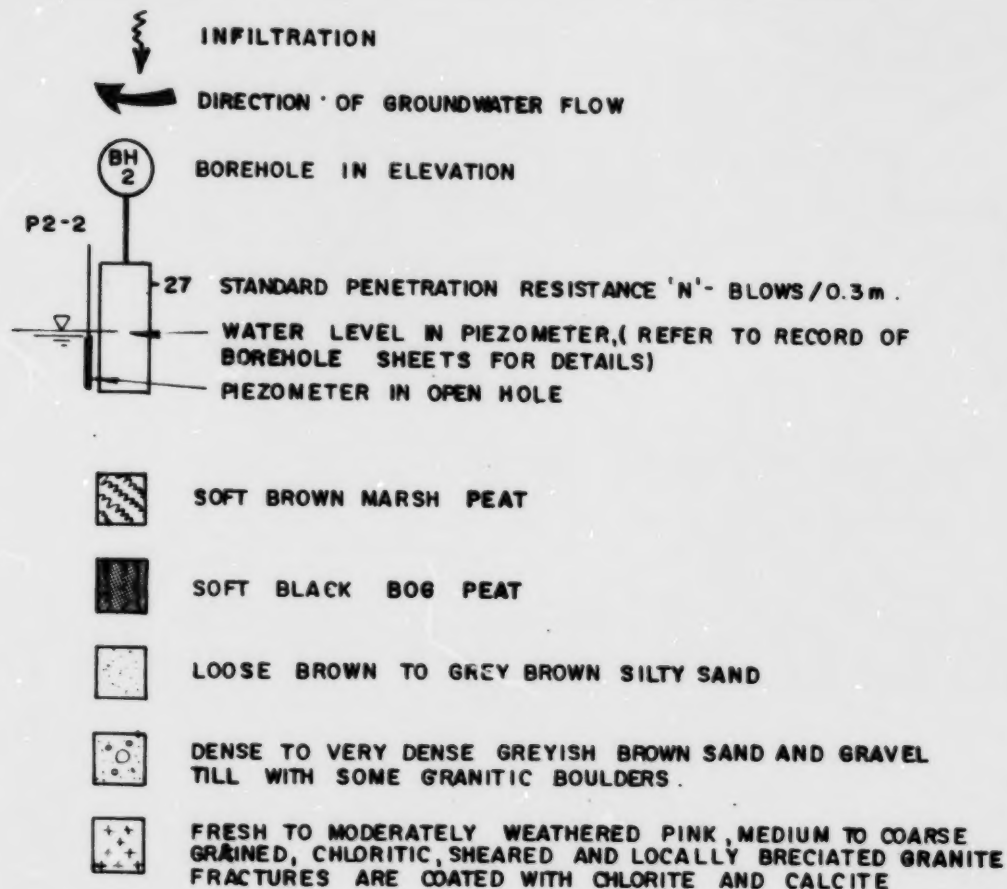
# SECTION A-A, STRATIGRAPHY AND GROUNDWATER CONDITIONS PORTLAND CREEK, NEWFOUNDLAND

FIGURE 10

EAST



## LEGEND



## NOTE

FOR LOCATION OF SECTION A-A REFER TO FIGURE 4

## SCALES

HORIZONTAL 1: 500

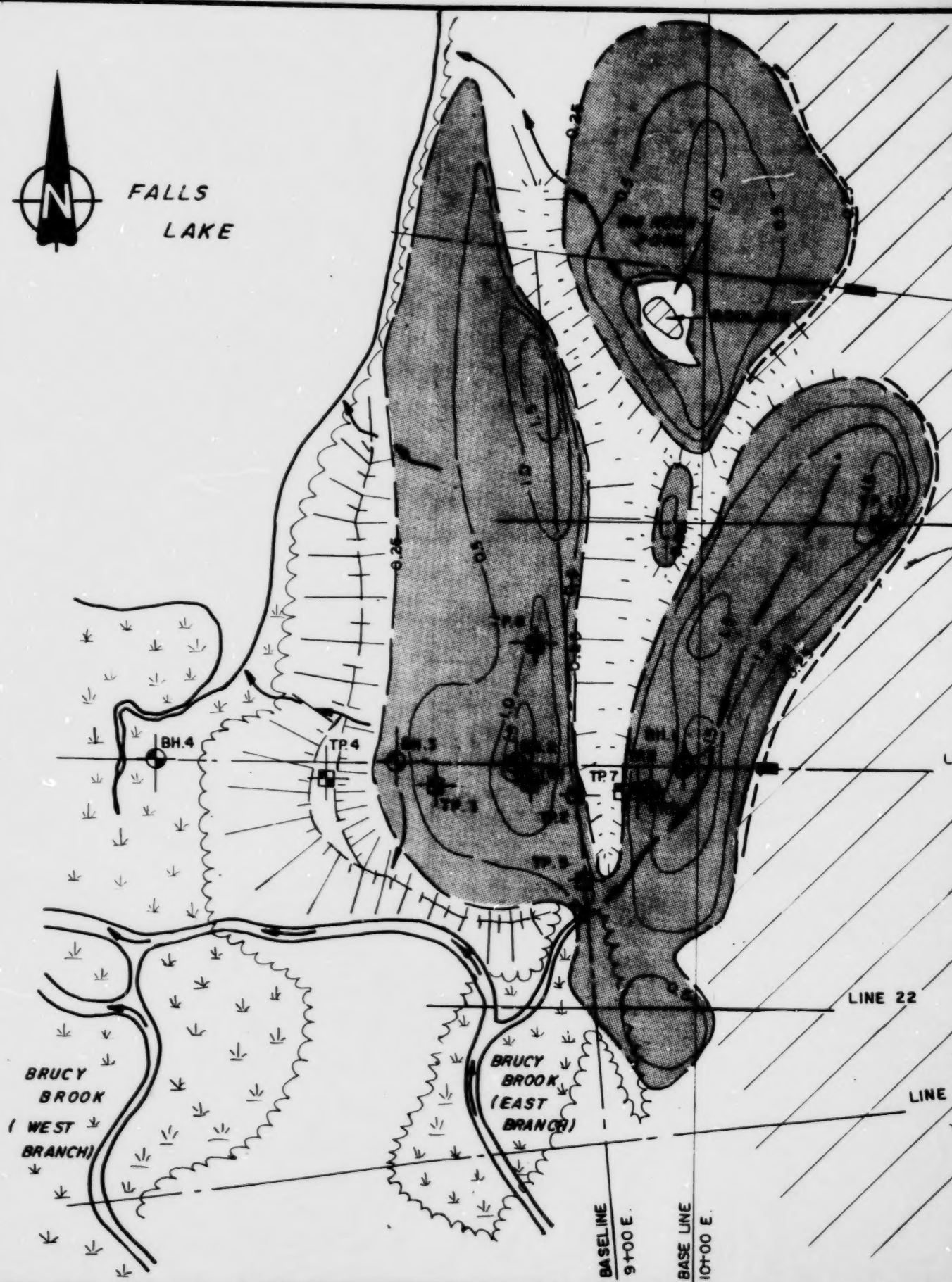
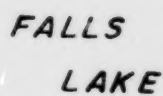
VERTICAL 1: 100

Date. APRIL 2, 1985  
Project. 041-5033

Golder Associates

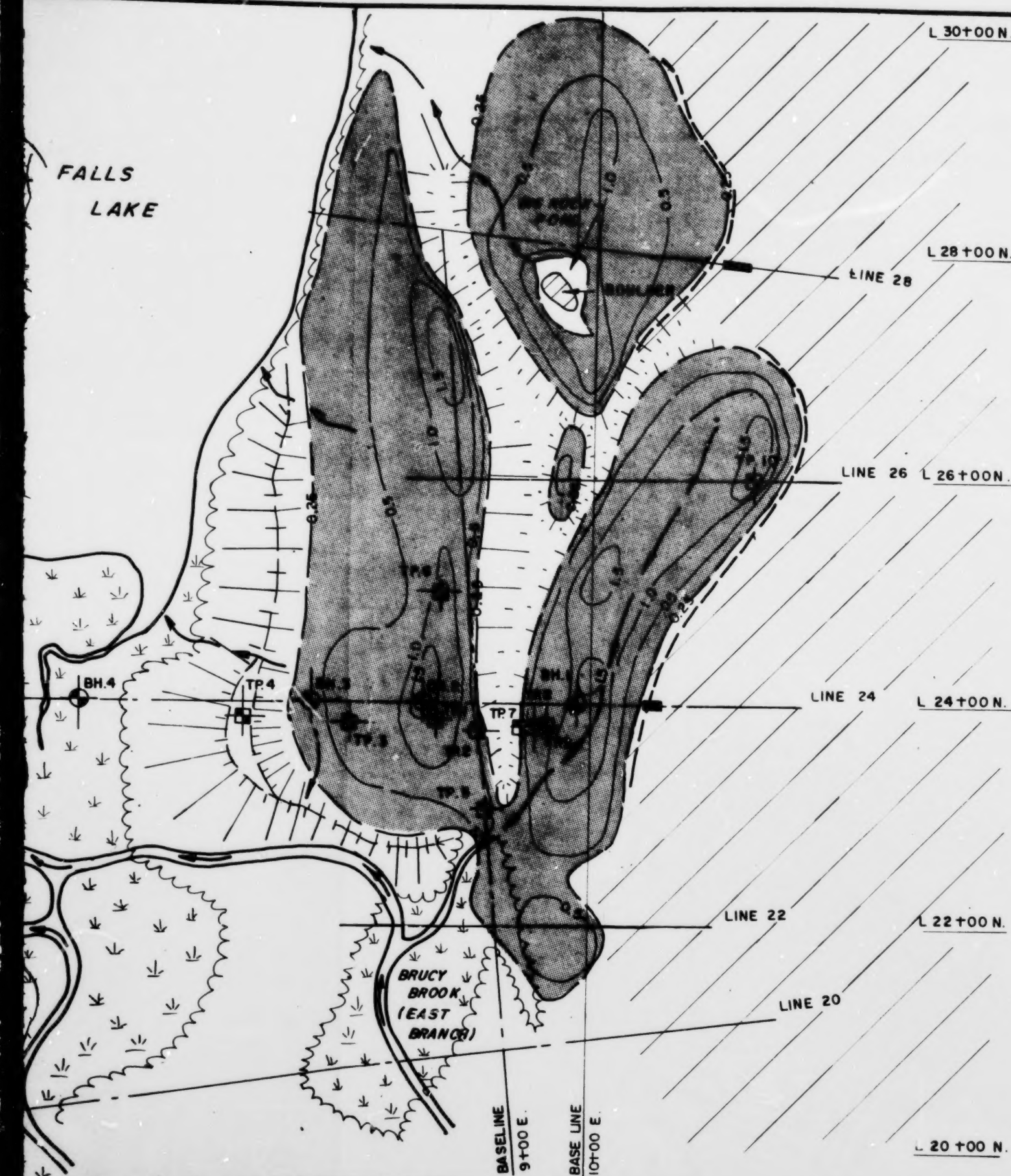
Drawn. D.W.  
Chkd. R.D.B.





PLAN SHOWING EXTENT AND DEPTH  
OF URANIFEROUS SPHAGNUM PEAT BOG  
PORTLAND CREEK, NEWFOUNDLAND

FIGURE II



LEGEND

- URANIFEROUS SPHAGNUM PEAT BOG
- GRANITE TALUS SLOPE
- MARSH PEAT
- EDGE OF FORESTED AREA
- DIRECTION OF SURFACE WATER FLOW
- BOREHOLE LOCATION IN PLAN
- TEST PIT LOCATION IN PLAN
- EXPLORATION TRENCH FROM PREVIOUS INVESTIGATIONS
- CUT PICKET LINE
- 0.5 PEAT CONTOUR IN METRES BELOW GROUND SURFACE
- TILL MORaine RIDGE
- GROUNDWATER SPRINGS

NOTE

DEPTH OF PEAT DETERMINED FROM HAND AUGER PROBINGS PUT DOWN AT 7.5m. INTERVALS ALONG PICKET LINE GRID, BOREHOLES AND TEST PITS.

PICKET LINE CHAINAGES IN FEET BASED APON PREEXISTING EXPLORATION GRID.

SCALE 10 0 10 20 30 40 50 100 METRES

SCALE 1:1200

Date... MAR. 29, 1985  
Project... 841-5033

Golder Associates

Drawn... D.M.  
Chkd... R.D.B.

APPENDIX A

SUBSURFACE INVESTIGATIONS

## LIST OF ABBREVIATIONS

The abbreviation commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

### I. SAMPLE TYPES

*AS* auger sample  
*CS* chunk sample  
*DO* drive open  
*DS* Denison type sample  
*FS* foil sample  
*RC* rock core  
*ST* slotted tube  
*TO* thin-walled, open  
*TP* thin-walled, piston  
*WS* wash sample

### II. PENETRATION RESISTANCES

#### Dynamic Penetration Resistance:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

#### Standard Penetration Resistance, *N*:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

*WH* sampler advanced by static weight—weight, hammer

*PH* sampler advanced by pressure—pressure, hydraulic

*PM* sampler advanced by pressure—pressure, manual

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

| <i>Relative Density</i> | <i>'N'</i><br>Blows 0.30m<br>or Blows ft. |
|-------------------------|-------------------------------------------|
| Very loose              | 0 to 4                                    |
| Loose                   | 4 to 10                                   |
| Compact                 | 10 to 30                                  |
| Dense                   | 30 to 50                                  |
| Very dense              | over 50                                   |

#### (b) Cohesive Soils

| <i>Consistency</i> | <i>kPa</i> | <i>'Cu'</i><br>psf. |
|--------------------|------------|---------------------|
| Very soft          | 0 to 12    | 0 to 250            |
| Soft               | 12 to 25   | 250 to 500          |
| Firm               | 25 to 50   | 500 to 1000         |
| Stiff              | 50 to 100  | 1000 to 2000        |
| Very stiff         | 100 to 200 | 2000 to 4000        |
| Hard               | over 200   | over 4000           |

### IV. SOIL TESTS

*C* consolidation test  
*H* hydrometer analysis  
*M* sieve analysis  
*MH* combined analysis, sieve and hydrometer<sup>1</sup>  
*Q* undrained triaxial<sup>2</sup>  
*R* consolidated undrained triaxial<sup>2</sup>  
*S* drained triaxial  
*U* unconfined compression  
*V* field vane test

#### NOTES:

<sup>1</sup>Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

<sup>2</sup>Undrained triaxial tests in which pore pressures are measured are shown as  $\bar{Q}$  or  $\bar{R}$ .



## LIST OF SYMBOLS

### I. GENERAL

|                           |                                     |
|---------------------------|-------------------------------------|
| $\tau$                    | = 3.1416                            |
| $e$                       | = base of natural logarithms 2.7183 |
| $\log_e a$ or $\ln a$     | natural logarithm of $a$            |
| $\log_{10} a$ or $\log a$ | logarithm of $a$ to base 10         |
| $t$                       | time                                |
| $g$                       | acceleration due to gravity         |
| $V$                       | volume                              |
| $W$                       | weight                              |
| $M$                       | moment                              |
| $F$                       | factor of safety                    |

### II. STRESS AND STRAIN

|                 |                                                        |
|-----------------|--------------------------------------------------------|
| $u$             | pore pressure                                          |
| $\sigma$        | normal stress                                          |
| $\sigma'$       | normal effective stress ( $\bar{\sigma}$ is also used) |
| $\tau$          | shear stress                                           |
| $\epsilon$      | linear strain                                          |
| $\epsilon_{xy}$ | shear strain                                           |
| $\nu$           | Poisson's ratio ( $\mu$ is also used)                  |
| $E$             | modulus of linear deformation (Young's modulus)        |
| $G$             | modulus of shear deformation                           |
| $K$             | modulus of compressibility                             |
| $\eta$          | coefficient of viscosity                               |

### III. SOIL PROPERTIES

#### (a) Unit weight

|            |                                                                 |
|------------|-----------------------------------------------------------------|
| $\gamma$   | unit weight of soil (bulk density)                              |
| $\gamma_s$ | unit weight of solid particles                                  |
| $\gamma_w$ | unit weight of water                                            |
| $\gamma_d$ | unit dry weight of soil (dry density)                           |
| $\gamma'$  | unit weight of submerged soil                                   |
| $G_s$      | specific gravity of solid particles $G_s = \gamma_s / \gamma_w$ |
| $e$        | void ratio                                                      |
| $n$        | porosity                                                        |
| $w$        | water content                                                   |
| $S_r$      | degree of saturation                                            |

#### (b) Consistency

|           |                                                          |
|-----------|----------------------------------------------------------|
| $w_L$     | liquid limit                                             |
| $w_P$     | plastic limit                                            |
| $I_P$     | plasticity index                                         |
| $w_S$     | shrinkage limit                                          |
| $I_L$     | liquidity index = $(w - w_P) / I_P$                      |
| $I_C$     | consistency index = $(w_L - w) / I_P$                    |
| $e_{max}$ | void ratio in loosest state                              |
| $e_{min}$ | void ratio in densest state                              |
| $D_r$     | relative density = $(e_{max} - e) / (e_{max} - e_{min})$ |

#### (c) Permeability

|     |                               |
|-----|-------------------------------|
| $h$ | hydraulic head or potential   |
| $q$ | rate of discharge             |
| $v$ | velocity of flow              |
| $i$ | hydraulic gradient            |
| $k$ | coefficient of permeability   |
| $j$ | seepage force per unit volume |

#### (d) Consolidation (one-dimensional)

|       |                                                                        |
|-------|------------------------------------------------------------------------|
| $m_v$ | coefficient of volume change<br>= $-\Delta e / (1 + e) \Delta \sigma'$ |
| $C_c$ | compression index = $-\Delta e / \Delta \log_{10} \sigma'$             |
| $c_c$ | coefficient of consolidation                                           |
| $T_v$ | time factor = $c_v d^2$ ( $d$ , drainage path)                         |
| $U$   | degree of consolidation                                                |

#### (e) Shear strength

|          |                                                     |
|----------|-----------------------------------------------------|
| $\tau_f$ | shear strength                                      |
| $c'$     | effective cohesion                                  |
| $\phi'$  | effective angle of shearing resistance, or friction |
| $c_u$    | apparent cohesion*                                  |
| $\phi_u$ | apparent angle of shearing resistance, or friction  |
| $\mu$    | coefficient of friction                             |
| $S_r$    | sensitivity                                         |

in terms of effective stress  
 $\tau_f = c' + \sigma' \tan \phi'$

in terms of total stress  
 $\tau_f = c_u + \sigma \tan \phi_u$

\*For the case of a saturated cohesive soil,  $\phi_u = 0$  and the undrained shear strength  $\tau_f = c_u$  is taken as half the undrained compressive strength.



## PROJECT 641-5053

BORING DATE AUG 24 AND 25, 1984

DATUM LOCAL

SAMPLER HAMMER, 63.6 kg.; DROP, 760 mm

PENETRATION TEST HAMMER, 63.6 kg; DROP, 760 mm

FORM: S-100 - 1% LOT 17% OF ORIGINAL SIZE

**Golder Associates**

DRAWN L.L.  
CHECKED RAB

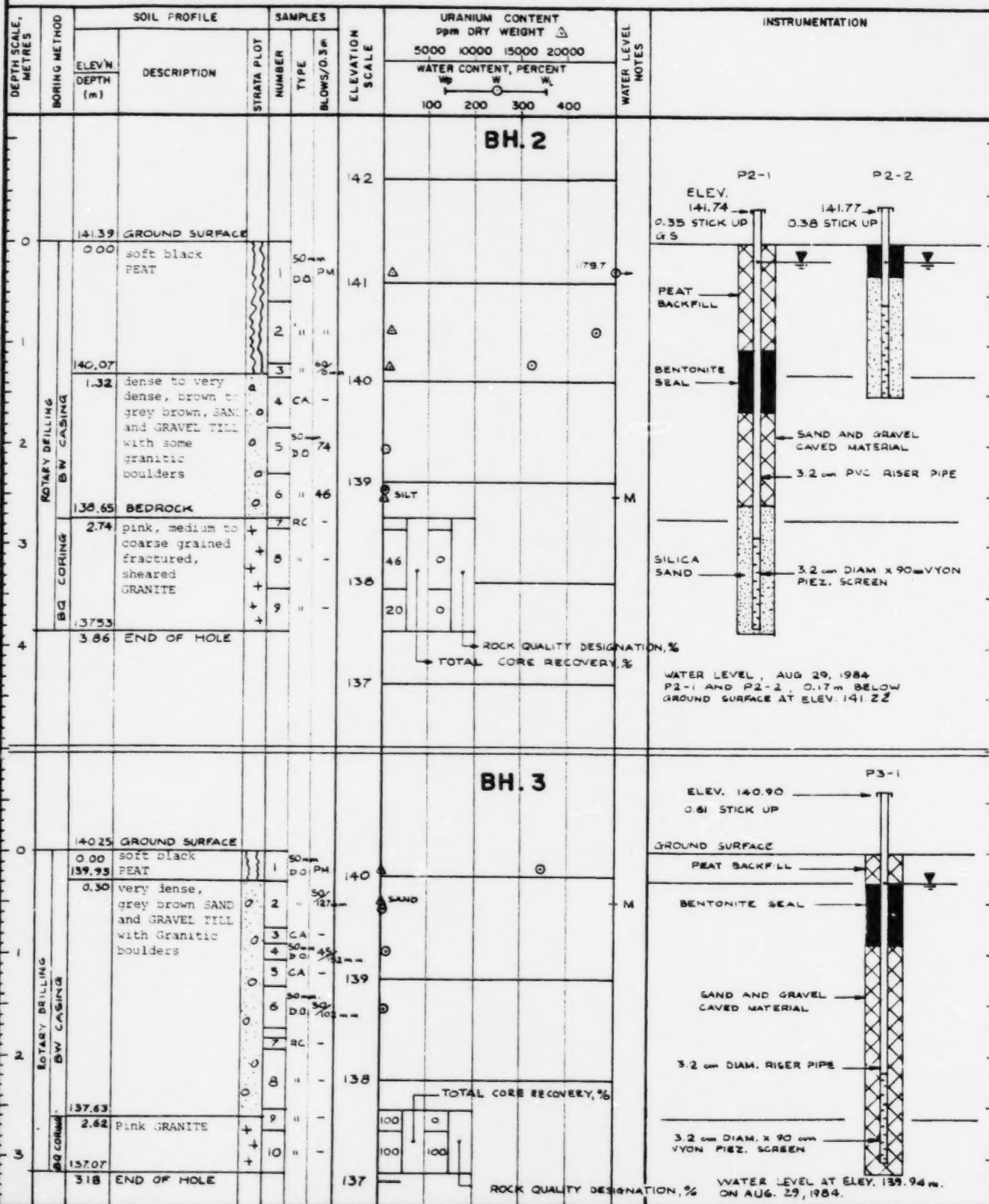
# RECORD OF BOREHOLES 2 AND 3

LOCATION See Figure 4

BORING DATE AUG 26 AND 27, 1984 DATUM LOCAL

SAMPLER HAMMER, 63.6 kg ; DROP, 760 mm

PENETRATION TEST HAMMER, 63.6 kg ; DROP, 760 mm



VERTICAL SCALE  
1:50 (METRIC)

Golder Associates

DRAWN L.L.  
CHECKED R.B.

# RECORD OF BOREHOLE 4

LOCATION See Figure 4

BORING DATE AUG 27, 1984

DATUM LOCAL

SAMPLER HAMMER, 63.6 kg.; DROP, 760 mm

PENETRATION TEST HAMMER, 63.6 kg.; DROP, 760 mm

| DEPTH SCALE,<br>METRES | BORING METHOD                | SOIL PROFILE            |                                                                                                    | SAMPLES     |        |          | ELEVATION<br>SCALE | URANIUM CONTENT<br>ppm DRY WEIGHT $\Delta$ |                        |       |       | WATER LEVEL<br>NOTES                                             | INSTRUMENTATION                                                                                                                                                                                                          |  |
|------------------------|------------------------------|-------------------------|----------------------------------------------------------------------------------------------------|-------------|--------|----------|--------------------|--------------------------------------------|------------------------|-------|-------|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|                        |                              | ELEV. N<br>DEPTH<br>(m) | DESCRIPTION                                                                                        | STRATA PLOT | NUMBER | TYPE     |                    | BLOWS/0.3m                                 | WATER CONTENT, PERCENT |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              |                         |                                                                                                    |             |        |          |                    |                                            | $W_p$                  | $W$   | $W_L$ |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              |                         |                                                                                                    |             |        |          |                    | 5000                                       | 10000                  | 15000 | 20000 |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              |                         |                                                                                                    |             |        |          |                    | $W_p$ — $W$ — $W_L$                        |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              |                         |                                                                                                    |             |        |          |                    | 100                                        | 200                    | 300   | 400   |                                                                  |                                                                                                                                                                                                                          |  |
| 0                      | ROTARY DRILLING<br>BW CASING | 138.48                  | GROUND SURFACE                                                                                     |             |        |          | 139                |                                            |                        |       |       |                                                                  | <p>ELEV. 139.21<br/>0.73 STICK UP</p> <p>GROUND SURFACE</p> <p>SAND AND GRAVEL BACKFILL</p> <p>BENTONITE SEAL</p> <p>SAND CAVED MATERIAL</p> <p>3.2 cm DIAM RISER PIPE</p> <p>3.2 cm DIAM x 90 VYON<br/>PIEZ. SCREEN</p> |  |
|                        |                              | 0.00                    | Soft brown PEAT                                                                                    |             | 1      | DO       |                    |                                            |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              | 0.20                    | Loose, brown<br>to grey brown<br>silty sand to<br>sand, trace to<br>some gravel<br><br>(Alluvium)  |             | 1A     | "        | 7                  | 138                                        |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              |                         |                                                                                                    |             | 2      | "        | 4                  |                                            |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              | 136.88                  |                                                                                                    |             | 3      | "        | 30<br>76           | 137                                        |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              | 1.60                    | Dense to very<br>dense, greyish<br>brown SAND and<br>GRAVEL TILL with<br>some granitic<br>boulders |             | 4      | AB<br>CC | 1                  |                                            |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
| 2                      |                              |                         |                                                                                                    |             | 5      | "        | 1                  | 136                                        |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
| 3                      |                              |                         |                                                                                                    |             | 6      | "        | 1                  |                                            |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
| 4                      |                              |                         |                                                                                                    |             |        |          |                    | 135                                        |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              | 134.90                  |                                                                                                    |             |        |          |                    | 134                                        |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        | 358                          | END OF HOLE             |                                                                                                    |             |        |          |                    |                                            |                        |       |       |                                                                  |                                                                                                                                                                                                                          |  |
|                        |                              |                         |                                                                                                    |             |        |          |                    |                                            |                        |       |       | WATER LEVEL IN PIEZOMETER AT ELEV.<br>138.07m. ON AUG. 29, 1984. |                                                                                                                                                                                                                          |  |

VERTICAL SCALE  
1:30 (METRIC)

Golder Associates

DRAWN 6.4  
CHECKED 3.23

PROJECT 84-1-50-23

FORM C-10-D-1K (10-1-84) 10% OF ORIGINAL SIZE

# RECORD OF TEST PIT 1

LOCATION See Figure 4 EXCAVATION DATE AUG 28, 1984 DATUM LOCAL

TEST PIT TYPE HAND DUG

TEST PIT SIZE 1m x 1m x 1.6m.

| SOIL PROFILE            |                                                                                                                                                                                                                                                                                                                       |             |               |             | URANIUM CONTENT |                        |     |     | ADDITIONAL<br>LAB. TESTING | GROUNDWATER<br>CONDITIONS |                                                                        |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------|-------------|-----------------|------------------------|-----|-----|----------------------------|---------------------------|------------------------------------------------------------------------|
| ELEV'N.<br>DEPTH<br>(m) | DESCRIPTION                                                                                                                                                                                                                                                                                                           | STRATA PLOT | SAMPLE NUMBER | SAMPLE TYPE | ELEVATION SCALE | ppm    Δ               |     |     |                            |                           |                                                                        |
|                         |                                                                                                                                                                                                                                                                                                                       |             |               |             |                 | 5000 10000 15000 20000 |     |     |                            |                           |                                                                        |
|                         |                                                                                                                                                                                                                                                                                                                       |             |               |             |                 | WATER CONTENT, PERCENT |     |     |                            |                           |                                                                        |
|                         |                                                                                                                                                                                                                                                                                                                       |             |               |             |                 | Wp                     | W   | WL  |                            |                           |                                                                        |
|                         |                                                                                                                                                                                                                                                                                                                       |             |               |             |                 | 100                    | 200 | 300 | 400                        |                           |                                                                        |
|                         |                                                                                                                                                                                                                                                                                                                       |             |               |             |                 | T.P. I                 |     |     |                            |                           |                                                                        |
|                         |                                                                                                                                                                                                                                                                                                                       |             |               |             | 142             |                        |     |     |                            |                           | ELEV.<br>142.31                                                        |
|                         |                                                                                                                                                                                                                                                                                                                       |             |               |             |                 |                        |     |     |                            |                           | 0.34m<br>STICK UP                                                      |
| 141.37                  | GROUND SURFACE                                                                                                                                                                                                                                                                                                        |             |               |             |                 |                        |     |     |                            |                           |                                                                        |
| 0.00                    | firm black peat with<br>buried roots and stumps<br>of dead spruce trees<br>overlying dense gravel                                                                                                                                                                                                                     |             | 5             | CS          |                 | Δ                      | ○   |     |                            |                           |                                                                        |
|                         |                                                                                                                                                                                                                                                                                                                       |             | 4             | "           | 141             | ○                      |     |     |                            | M                         | PEAT<br>BACKFILL                                                       |
|                         |                                                                                                                                                                                                                                                                                                                       |             | 3             | "           |                 | Δ                      | ○   |     |                            |                           | 0.9m VYON<br>PIEZOMETER<br>SCREEN                                      |
|                         |                                                                                                                                                                                                                                                                                                                       |             | 2             | "           |                 |                        | Δ   |     | ○                          |                           | 3.2 cm.<br>DIAM. PVC<br>STANDPIPE                                      |
|                         |                                                                                                                                                                                                                                                                                                                       |             | 1             | "           | 140             | Δ                      | ○   |     |                            |                           | SILICA<br>SAND                                                         |
| 139.77                  | BOTTOM OF TEST PIT                                                                                                                                                                                                                                                                                                    |             | 6             | "           |                 | Δ                      |     |     |                            |                           |                                                                        |
| 1.60                    | Note: Test pit was<br>hand dug to a depth of<br>1.3m with only minor<br>seepage inflow from<br>ground surface. When<br>shovel was pushed below<br>1.4 to 1.5m the pit<br>immediately flooded.<br>Water was controlled<br>during sampling by<br>bailing the water that<br>continued to enter from<br>beneath the peat. |             |               |             | 139             |                        |     |     |                            |                           | WATER LEVEL AT<br>ELEV. 141.32 m.<br>GROUND SURFACE<br>ON AUG 28, 1984 |

VERTICAL SCALE  
1: 20 (METRIC)

Golder Associates

DRAWN L.F.  
CHECKED RDB

# RECORD OF TEST PIT 2

LOCATION See Figure 4 EXCAVATION DATE AUG 28, 1984 DATUM LOCAL  
TEST PIT TYPE HAND DUG TEST PIT SIZE 1.5m x 2.0m. x 0.75m.

| SOIL PROFILE            |                                                                                      |             |               |             | URANIUM CONTENT |                        |     |                | ADDITIONAL<br>LAB. TESTING | GROUNDWATER<br>CONDITIONS |                     |
|-------------------------|--------------------------------------------------------------------------------------|-------------|---------------|-------------|-----------------|------------------------|-----|----------------|----------------------------|---------------------------|---------------------|
| ELEV'N.<br>DEPTH<br>(m) | DESCRIPTION                                                                          | STRATA PLOT | SAMPLE NUMBER | SAMPLE TYPE | ELEVATION SCALE | ppm $\Delta$           |     |                |                            |                           |                     |
|                         |                                                                                      |             |               |             |                 | 5000 10000 15000 20000 |     |                |                            |                           |                     |
|                         |                                                                                      |             |               |             |                 | WATER CONTENT, PERCENT |     |                |                            |                           |                     |
|                         |                                                                                      |             |               |             |                 | W <sub>p</sub>         | W   | W <sub>L</sub> |                            |                           |                     |
|                         |                                                                                      |             |               |             |                 | 100                    | 200 | 300            | 400                        |                           |                     |
| T.P. 2 (WEST SIDE)      |                                                                                      |             |               |             |                 |                        |     |                |                            |                           |                     |
| 141.89                  | GROUND SURFACE                                                                       |             |               |             | 142             |                        |     |                |                            |                           | ELEV.<br>142.58 →   |
| 0.00                    | firm black peat with roots and stumps of dead, buried spruce trees.                  |             | 3             | C.S.        |                 | $\Delta$               |     |                |                            |                           | 0.69 m.<br>STICK UP |
| 141.39                  |                                                                                      |             | 4             | "           |                 | $\Delta$               |     |                |                            |                           |                     |
| 0.50                    | very dense, dark brown to grey, poorly sorted sand and gravel with granitic boulders |             | 5             | "           |                 | $\Delta$ SAND          |     |                |                            |                           |                     |
| 141.14                  |                                                                                      |             |               |             |                 |                        |     |                |                            |                           |                     |
| 0.75                    | BOTTOM OF TEST PIT                                                                   |             |               |             | 141             |                        |     |                |                            |                           |                     |
|                         | NOTE: Granite boulders varied from 0.1 to 0.5m dia.                                  |             |               |             |                 |                        |     |                |                            |                           |                     |
| T.P. 2 (EAST SIDE)      |                                                                                      |             |               |             |                 |                        |     |                |                            |                           |                     |
| 141.89                  | GROUND SURFACE                                                                       |             |               |             | 142             |                        |     |                |                            |                           |                     |
| 0.00                    | firm black peat with roots and stumps of dead, buried spruce trees                   |             | 2             | C.S.        |                 | $\Delta$               |     |                |                            |                           |                     |
| 141.64                  |                                                                                      |             |               |             |                 |                        |     |                |                            |                           |                     |
| 0.25                    | very dense, dark brown to grey, poorly sorted sand and gravel with granitic boulders |             | 1             | "           |                 | $\Delta$               |     |                |                            |                           |                     |
| 141.39                  |                                                                                      |             |               |             |                 |                        |     |                |                            |                           |                     |
| 0.50                    | BOTTOM OF TEST PIT                                                                   |             |               |             | 141             |                        |     |                |                            |                           |                     |
|                         | NOTE: Granite boulders varied from 0.1 to 0.5m dia.                                  |             |               |             |                 |                        |     |                |                            |                           |                     |

VERTICAL SCALE  
1: 20 (METRIC)

Golder Associates

DRAWN L.L.  
CHECKED R.P.B.



# RECORD OF TEST PITS 3 AND 4

LOCATION See Figure 4

EXCAVATION DATE AUG 28, 1984

DATUM LOCAL

TEST PIT TYPE HAND DUG

TEST PIT SIZE 1.5x1.5x0.75m; 1.5x0.5x0.75m.

| SOIL PROFILE            |                                                                                                                                  |             |                                                       | SAMPLE NUMBER | SAMPLE TYPE | ELEVATION SCALE | URANIUM CONTENT<br>ppm $\Delta$ |     |     |             | ADDITIONAL<br>LAB. TESTING                                                       | GROUNDWATER<br>CONDITIONS |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------------------|---------------|-------------|-----------------|---------------------------------|-----|-----|-------------|----------------------------------------------------------------------------------|---------------------------|
| ELEV'N.<br>DEPTH<br>(m) | DESCRIPTION                                                                                                                      | STRATA PLOT | 5000 10000 15000 20000                                |               |             |                 |                                 |     |     |             |                                                                                  |                           |
|                         |                                                                                                                                  |             | RADIOACTIVITY<br>$\Delta$ R/hr $\bullet$              |               |             |                 |                                 |     |     |             |                                                                                  |                           |
|                         |                                                                                                                                  |             | WATER CONTENT, PERCENT<br>Wp $\bullet$ W $\bullet$ WL |               |             |                 |                                 |     |     |             |                                                                                  |                           |
|                         |                                                                                                                                  |             |                                                       |               |             | 100             | 200                             | 300 | 400 |             |                                                                                  |                           |
| <b>T.P. 3</b>           |                                                                                                                                  |             |                                                       |               |             |                 |                                 |     |     |             |                                                                                  |                           |
|                         |                                                                                                                                  |             |                                                       |               |             | 141             |                                 |     |     |             |                                                                                  |                           |
| 140.71                  | GROUND SURFACE                                                                                                                   |             |                                                       |               |             |                 |                                 |     |     |             |                                                                                  |                           |
| 0.00                    | firm, black peat with buried roots and stumps of dead spruce trees                                                               |             | 3                                                     | C.S.          | $\Delta$    |                 |                                 |     |     | $\odot$     | minor seepage entered pit from peat and contact between peat & underlying gravel |                           |
|                         |                                                                                                                                  |             | 4                                                     | "             | $\Delta$    |                 |                                 |     |     |             |                                                                                  |                           |
| 140.21                  |                                                                                                                                  |             | 5                                                     | "             | $\Delta$    |                 |                                 |     |     | $\odot$ 5+9 |                                                                                  |                           |
| 0.50                    | very brownish grey sand and gravel with granitic boulders up to .6 m dia.                                                        |             | 1                                                     | "             | $\Delta$    |                 |                                 |     |     | $\odot$     |                                                                                  |                           |
| 139.96                  |                                                                                                                                  |             | 2                                                     | "             | $\Delta$    |                 |                                 |     |     |             |                                                                                  |                           |
| 0.75                    | BOTTOM OF TEST PIT<br>NOTE: 0.48-0.50 - light grey clayey silt at base of peat                                                   |             |                                                       |               |             | 140             |                                 |     |     |             |                                                                                  |                           |
| <b>T.P. 4</b>           |                                                                                                                                  |             |                                                       |               |             |                 |                                 |     |     |             |                                                                                  |                           |
| 140.36                  | GROUND SURFACE                                                                                                                   |             |                                                       |               |             |                 |                                 |     |     |             |                                                                                  |                           |
| 0.00                    | reddish brown forest humus and moss, live spruce trees                                                                           |             | 1                                                     | C.S.          | $\Delta$    |                 |                                 |     |     | $\odot$     | TEST PIT DRY ON AUG 28, 1984                                                     |                           |
| 140.11                  |                                                                                                                                  |             | 2                                                     | "             | $\Delta$    |                 |                                 |     |     |             |                                                                                  |                           |
| 0.25                    | light whitish grey, loose, leached Soil (A Horizon)                                                                              |             | 3                                                     | "             | $\Delta$    |                 |                                 |     |     |             |                                                                                  |                           |
| 139.99                  |                                                                                                                                  |             | 4                                                     | "             | $\Delta$    |                 |                                 |     |     |             |                                                                                  |                           |
| 0.37                    | Reddish brown, very dense granitic sand and gravel (B Horizon)                                                                   |             | 5                                                     | "             | $\Delta$    |                 |                                 |     |     |             |                                                                                  |                           |
| 139.61                  |                                                                                                                                  |             | 6                                                     | "             | $\Delta$    |                 |                                 |     |     |             |                                                                                  |                           |
| 0.75                    | BOTTOM OF TEST PIT<br>NOTE: Dark reddish brown iron oxide cementation occurs from 0.37 to 0.50 m<br>Refusal to digging at 0.75 m |             |                                                       |               |             | 139             |                                 |     |     |             |                                                                                  |                           |

VERTICAL SCALE  
1:20 (METRIC)

Golder Associates

DRAWN L.L.  
CHECKED RRB

# RECORD OF TEST PITS 5 AND 6

LOCATION See Figure 4

EXCAVATION DATE AUG 28, 1984

DATUM LOCAL

TEST PIT TYPE HAND DUG

TEST PIT SIZE 2.0x1.0x0.9m; 1.5mx1.4x1.1m.

| SOIL PROFILE            |                                                                                                                   |             |               |             | ELEVATION SCALE        | URANIUM CONTENT<br>ppm $\Delta$       |  | ADDITIONAL<br>LAB. TESTING | GROUNDWATER<br>CONDITIONS                                                                                             |  |  |
|-------------------------|-------------------------------------------------------------------------------------------------------------------|-------------|---------------|-------------|------------------------|---------------------------------------|--|----------------------------|-----------------------------------------------------------------------------------------------------------------------|--|--|
| ELEV'N.<br>DEPTH<br>(m) | DESCRIPTION                                                                                                       | STRATA PLOT | SAMPLE NUMBER | SAMPLE TYPE |                        | 5000 10000 15000 20000                |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             |               |             |                        | RADIOACTIVITY<br>$\mu$ R/hr $\bullet$ |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             |               |             |                        | 100 200 300 400                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             |               |             | WATER CONTENT, PERCENT |                                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             |               |             | Wp W WL                |                                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             |               |             | 100 200 300 400        |                                       |  |                            |                                                                                                                       |  |  |
| <b>T.P. 5</b>           |                                                                                                                   |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |
| 140.34                  | GROUND SURFACE                                                                                                    |             |               |             |                        |                                       |  |                            | G.S.                                                                                                                  |  |  |
| 0.00                    | firm, black peat with numerous buried roots and stumps of dead spruce trees; sharp contact with underlying gravel |             | 1             | C.S.        |                        |                                       |  |                            | <p>pit slowly flooded overnight to or slightly above level of adjacent creek</p> <p>Water level AT ELEV. 140.14m.</p> |  |  |
|                         |                                                                                                                   |             | 2             | "           |                        |                                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             | 3             | "           |                        |                                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             | 4             | "           |                        |                                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             | 5             | "           |                        |                                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             | 6             | "           |                        |                                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             | 7             | "           |                        |                                       |  |                            |                                                                                                                       |  |  |
| 139.64                  |                                                                                                                   |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |
| 0.70                    | dense light to medium brownish grey granitic sand and gravel with                                                 |             | 8             | "           |                        |                                       |  |                            | M                                                                                                                     |  |  |
| 139.44                  |                                                                                                                   |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |
| 0.90                    | BOTTOM OF TEST PIT boulders up to .5m dia.                                                                        |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |
| <b>T.P. 6</b>           |                                                                                                                   |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |
| 141.92                  | GROUND SURFACE                                                                                                    |             |               |             |                        |                                       |  |                            | ELEV 142.60 →                                                                                                         |  |  |
| 0.00                    | firm, black peat with numerous buried roots and stumps of dead spruce trees overlying dense gravel                |             | 1             | C.S.        |                        |                                       |  |                            | 0.58 m STICK UP                                                                                                       |  |  |
|                         |                                                                                                                   |             | 2             | "           |                        |                                       |  |                            | <p>PEAT BACKFILL</p> <p>3.2 cm. SLOTTED PVC. WITH BURLAP WRAPPING</p>                                                 |  |  |
|                         |                                                                                                                   |             | 3             | "           |                        |                                       |  |                            |                                                                                                                       |  |  |
|                         |                                                                                                                   |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |
| 140.82                  |                                                                                                                   |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |
| 1.10                    | BOTTOM OF TEST PIT                                                                                                |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |
|                         | Test pit 6 flooded when dug below depth of 0.75m from water rushing in from base of peat.                         |             |               |             |                        |                                       |  |                            | WATER LEVEL AT ELEV. 141.52m. GROUND SURFACE ON AUG 28, 1984                                                          |  |  |
|                         | -bailing could not cope with flow                                                                                 |             |               |             |                        |                                       |  |                            |                                                                                                                       |  |  |

VERTICAL SCALE

1:20 (METRIC)

Golder Associates

DRAWN L.L.  
CHECKED RDB

# RECORD OF TEST PITS 7 AND 8

LOCATION See Figure 4

EXCAVATION DATE AUG 28, 1984

DATUM LOCAL

TEST PIT TYPE HAND DUG

TEST PIT SIZE 1.5x0.5mx0.8m.; 1.0x1.0x0.65m.

| SOIL PROFILE                                            |                                                                                                                 |             |               |             | URANIUM CONTENT<br>ppm $\Delta$ |                                       |     |     | ADDITIONAL<br>LAB. TESTING | GROUNDWATER<br>CONDITIONS |      |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-------------|---------------|-------------|---------------------------------|---------------------------------------|-----|-----|----------------------------|---------------------------|------|
| ELEV'N.<br>DEPTH<br>(m)                                 | DESCRIPTION                                                                                                     | STRATA PLOT | SAMPLE NUMBER | SAMPLE TYPE | ELEVATION SCALE                 | RADIOACTIVITY<br>$\mu R/hr$ $\bullet$ |     |     |                            |                           |      |
|                                                         |                                                                                                                 |             |               |             |                                 | WATER CONTENT, PERCENT                |     |     |                            |                           |      |
|                                                         |                                                                                                                 |             |               |             |                                 | Wp                                    | W   | WL  |                            |                           |      |
|                                                         |                                                                                                                 |             |               |             |                                 | 100                                   | 200 | 300 | 400                        |                           |      |
| <b>TP. 7</b>                                            |                                                                                                                 |             |               |             |                                 |                                       |     |     |                            |                           |      |
| 144.39                                                  | GROUND SURFACE                                                                                                  |             |               |             |                                 |                                       |     |     |                            |                           | G.S. |
| 0.00                                                    | reddish brown forest humus and spruce tree roots                                                                |             | 1             | C.S.        |                                 |                                       |     |     |                            |                           |      |
| 144.09                                                  |                                                                                                                 |             |               |             |                                 |                                       |     |     |                            |                           |      |
| 0.30                                                    | dense, light whitish grey, leached sand and gravel (A Horizon)                                                  |             | 2             | "           |                                 |                                       |     |     |                            | M                         |      |
| 143.89                                                  |                                                                                                                 |             |               |             |                                 |                                       |     |     |                            |                           |      |
| 0.5                                                     | very dense, dark brown to reddish brown, sand and gravel (B Horizon)                                            |             | 3             | "           |                                 |                                       |     |     |                            | M                         |      |
| 143.59                                                  |                                                                                                                 |             |               |             |                                 |                                       |     |     |                            |                           |      |
| 0.80                                                    | BOTTOM OF TEST PIT<br>Refusal to digging at .8m<br>NOTE: Sand and gravel is partially cemented with iron oxides |             |               |             |                                 |                                       |     |     |                            |                           |      |
| <b>WATER LEVEL AT ELEV. 144.37 m. ON AUG. 29, 1984.</b> |                                                                                                                 |             |               |             |                                 |                                       |     |     |                            |                           |      |
| <b>T.P. 8</b>                                           |                                                                                                                 |             |               |             |                                 |                                       |     |     |                            |                           |      |
| 143.81                                                  | GROUND SURFACE                                                                                                  |             |               |             |                                 |                                       |     |     |                            |                           | G.S. |
| 0.00                                                    | firm black peat with buried roots and stumps of dead spruce trees                                               |             | 1             | C.S.        |                                 |                                       |     |     |                            |                           |      |
|                                                         |                                                                                                                 |             | 2             | "           |                                 |                                       |     |     |                            |                           |      |
|                                                         |                                                                                                                 |             | 3             | "           |                                 |                                       |     |     |                            |                           |      |
| 143.36                                                  |                                                                                                                 |             | 4             | "           |                                 |                                       |     |     |                            |                           |      |
| 0.45                                                    | brownish grey, dense granitic sand and gravel                                                                   |             | 5             | "           |                                 |                                       |     |     |                            |                           |      |
| 143.16                                                  |                                                                                                                 |             |               |             |                                 |                                       |     |     |                            |                           |      |
| 0.65                                                    | BOTTOM OF TEST PIT<br>NOTE: Material is easier to dig than gravels encountered in the other test pits           |             |               |             |                                 |                                       |     |     |                            |                           |      |
| <b>WATER LEVEL AT ELEV. 143.46 m. ON AUG. 28, 1984.</b> |                                                                                                                 |             |               |             |                                 |                                       |     |     |                            |                           |      |

VERTICAL SCALE  
1: 20 (METRIC)

Golder Associates

DRAWN L.L.  
CHECKED BDB

# RECORD OF TEST PITS 9 AND 10

LOCATION See Figure 4

EXCAVATION DATE AUG 28, 1984

DATUM LOCAL

TEST PIT TYPE HAND DUG

TEST PIT SIZE 1.5 x 1.5 x 0.75m.; 5.0 x 1.0 x 1.4m.

| SOIL PROFILE            |                                                                                                                                                                                             |             |               |             | ELEVATION SCALE        | URANIUM CONTENT<br>ppm $\Delta$       |  | ADDITIONAL<br>LAB. TESTING | GROUNDWATER<br>CONDITIONS                                                    |  |  |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------|-------------|------------------------|---------------------------------------|--|----------------------------|------------------------------------------------------------------------------|--|--|
| ELEV'N.<br>DEPTH<br>(m) | DESCRIPTION                                                                                                                                                                                 | STRATA PLOT | SAMPLE NUMBER | SAMPLE TYPE |                        | 5000 10000 15000 20000                |  |                            |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             |               |             |                        | RADIOACTIVITY<br>$\mu R/hr$ $\bullet$ |  |                            |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             |               |             |                        | 100 200 300 400                       |  |                            |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             |               |             | WATER CONTENT, PERCENT |                                       |  |                            |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             |               |             | Wp W WL                |                                       |  |                            |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             |               |             | 100 200 300 400        |                                       |  |                            |                                                                              |  |  |
| <b>TP. 9</b>            |                                                                                                                                                                                             |             |               |             |                        |                                       |  |                            |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             |               |             | 144                    |                                       |  |                            | 0.47m.<br>STICK UP                                                           |  |  |
| 143.71                  | GROUND SURFACE                                                                                                                                                                              |             |               |             |                        |                                       |  |                            |                                                                              |  |  |
| 0.00                    | firm, black peat with numerous buried roots and stumps of dead spruce trees                                                                                                                 |             | 1             | C.S.        |                        |                                       |  | 576 $\bullet$              | PEAT BACKFILL                                                                |  |  |
|                         |                                                                                                                                                                                             |             | 2             | "           |                        |                                       |  | $\bullet$                  | 3.2 cm.                                                                      |  |  |
|                         |                                                                                                                                                                                             |             | 3             | "           |                        |                                       |  | $\bullet$                  | SLOTTED PVC. WITH BURLAP WRAPPING                                            |  |  |
| 143.01                  |                                                                                                                                                                                             |             |               |             |                        |                                       |  |                            | SILICA                                                                       |  |  |
| 142.96                  | sand and gravel                                                                                                                                                                             |             |               |             | 143                    |                                       |  |                            | SAND                                                                         |  |  |
| 0.75                    | BOTTOM OF TEST PIT<br>Pit flooded from surface inflow & seepage from peat. Sampling was completed while bailing water                                                                       |             |               |             |                        |                                       |  |                            | WATER LEVEL AT ELEV. 143.49m. ON AUG. 28, 1984.                              |  |  |
| <b>T.P. 10</b>          |                                                                                                                                                                                             |             |               |             |                        |                                       |  |                            |                                                                              |  |  |
| 147.21                  | GROUND SURFACE                                                                                                                                                                              |             |               |             |                        |                                       |  |                            |                                                                              |  |  |
| 0.00                    | firm, black peat with numerous buried roots and stumps of dead spruce trees<br>-peat is draped over toe of talus slope<br>-granite boulders were encountered at depth of 1.5m below surface |             | 1             | C.S.        | 147                    |                                       |  | 641 $\bullet$              | SPRING WATER WAS DISCHARGING AT SURFACE PRIOR TO PIT EXCAVATION AUG 28, 1984 |  |  |
|                         |                                                                                                                                                                                             |             | 2             | "           |                        |                                       |  | 525 $\bullet$              | SPRING FLOWED FROM PIT AT APPROX. 6-8 L/min                                  |  |  |
|                         |                                                                                                                                                                                             |             | 3             | "           |                        |                                       |  | 515 $\bullet$              |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             | 4             | "           |                        |                                       |  | $\Delta$ 534 $\bullet$     |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             | 5             | "           |                        |                                       |  | $\bullet$                  |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             | 6             | "           |                        |                                       |  | $\Delta$ $\bullet$         |                                                                              |  |  |
|                         |                                                                                                                                                                                             |             | 7             | "           | 146                    |                                       |  | 532 $\bullet$              |                                                                              |  |  |
| 145.81                  |                                                                                                                                                                                             |             |               |             |                        |                                       |  |                            |                                                                              |  |  |
| 1.40                    | BOTTOM OF TEST PIT                                                                                                                                                                          |             |               |             |                        |                                       |  |                            |                                                                              |  |  |

VERTICAL SCALE  
1:20 (METRIC)

Golder Associates

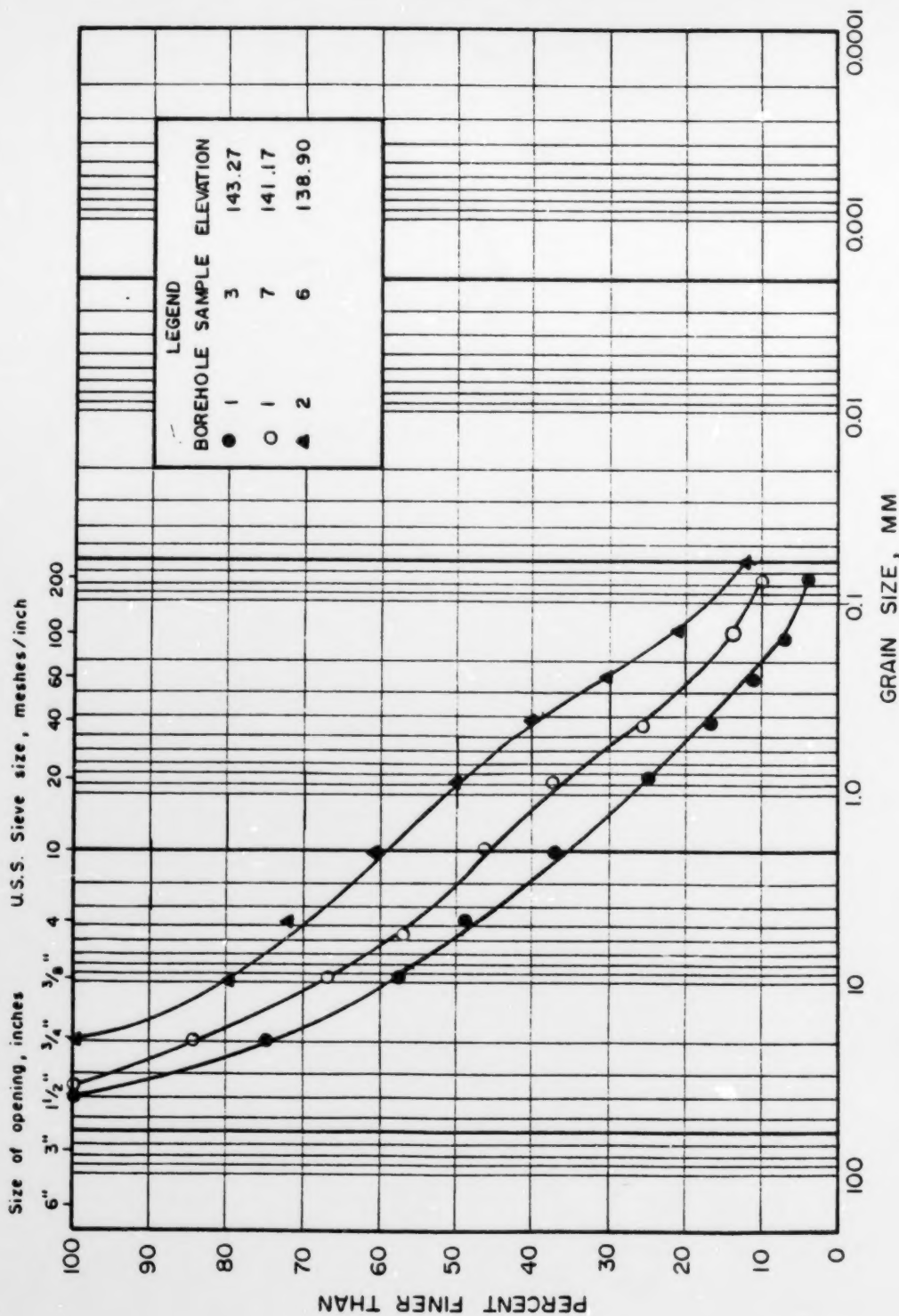
DRAWN L.L.  
CHECKED PDB



# GRAIN SIZE DISTRIBUTION TILL

FIGURE A-1

M.I.T. GRAIN SIZE SCALE



| COBBLE<br>SIZE | COARSE      | MEDIUM | FINE | SAND SIZE |        |      | SILT SIZE | CLAY SIZE |              |
|----------------|-------------|--------|------|-----------|--------|------|-----------|-----------|--------------|
|                | GRAVEL SIZE |        |      | COARSE    | MEDIUM | FINE |           |           | FINE GRAINED |

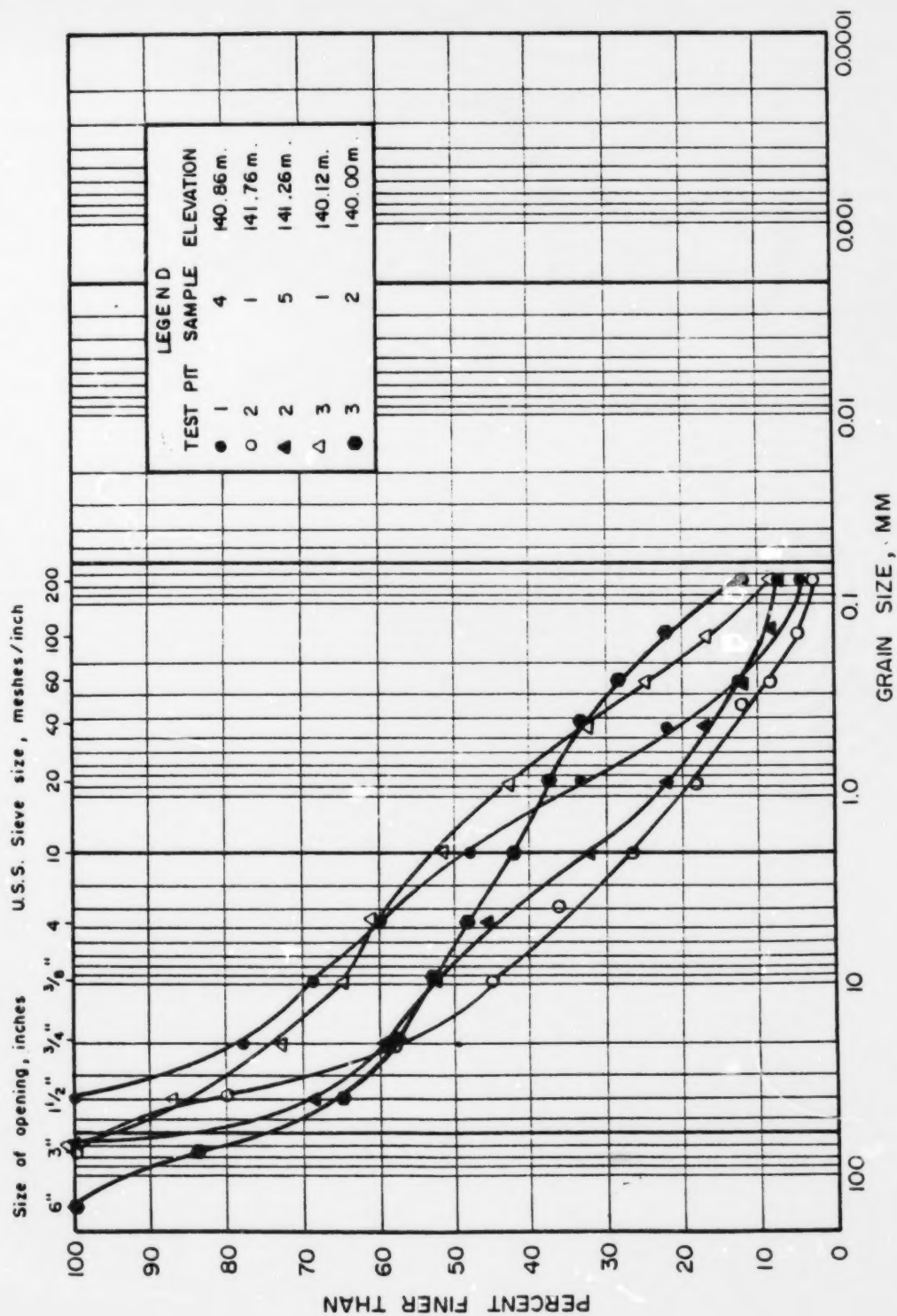
Golder Associates



GRAIN SIZE DISTRIBUTION  
TILL

FIGURE A-2

M.I.T. GRAIN SIZE SCALE



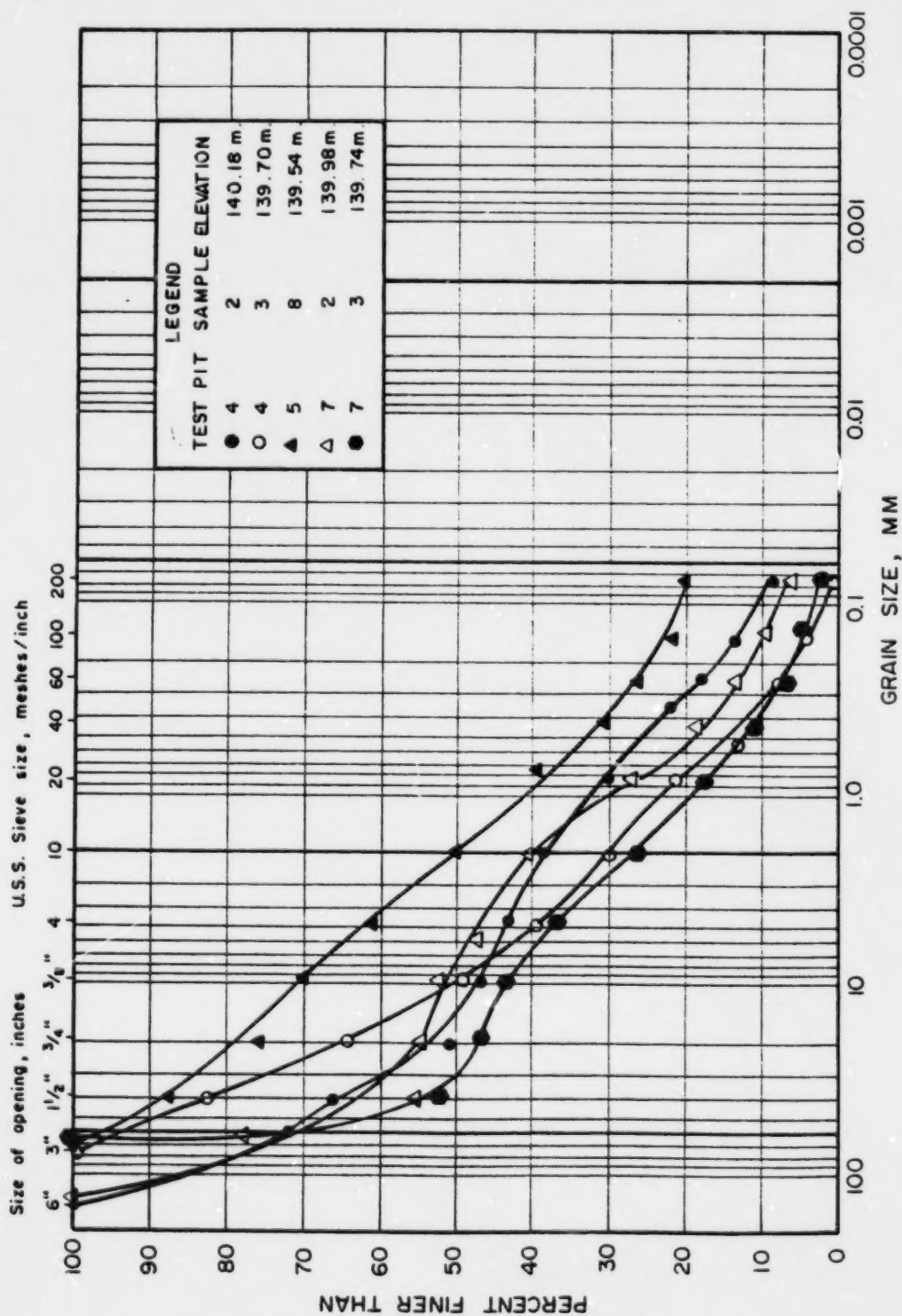
| COBBLE<br>SIZE | COARSE      | MEDIUM | FINE | SAND SIZE |        |      | SILT SIZE | CLAY SIZE    |  |
|----------------|-------------|--------|------|-----------|--------|------|-----------|--------------|--|
|                | GRAVEL SIZE |        |      | COARSE    | MEDIUM | FINE |           | FINE GRAINED |  |

Golder Associates

GRAIN SIZE DISTRIBUTION  
TILL

FIGURE A-3

M.I.T. GRAIN SIZE SCALE



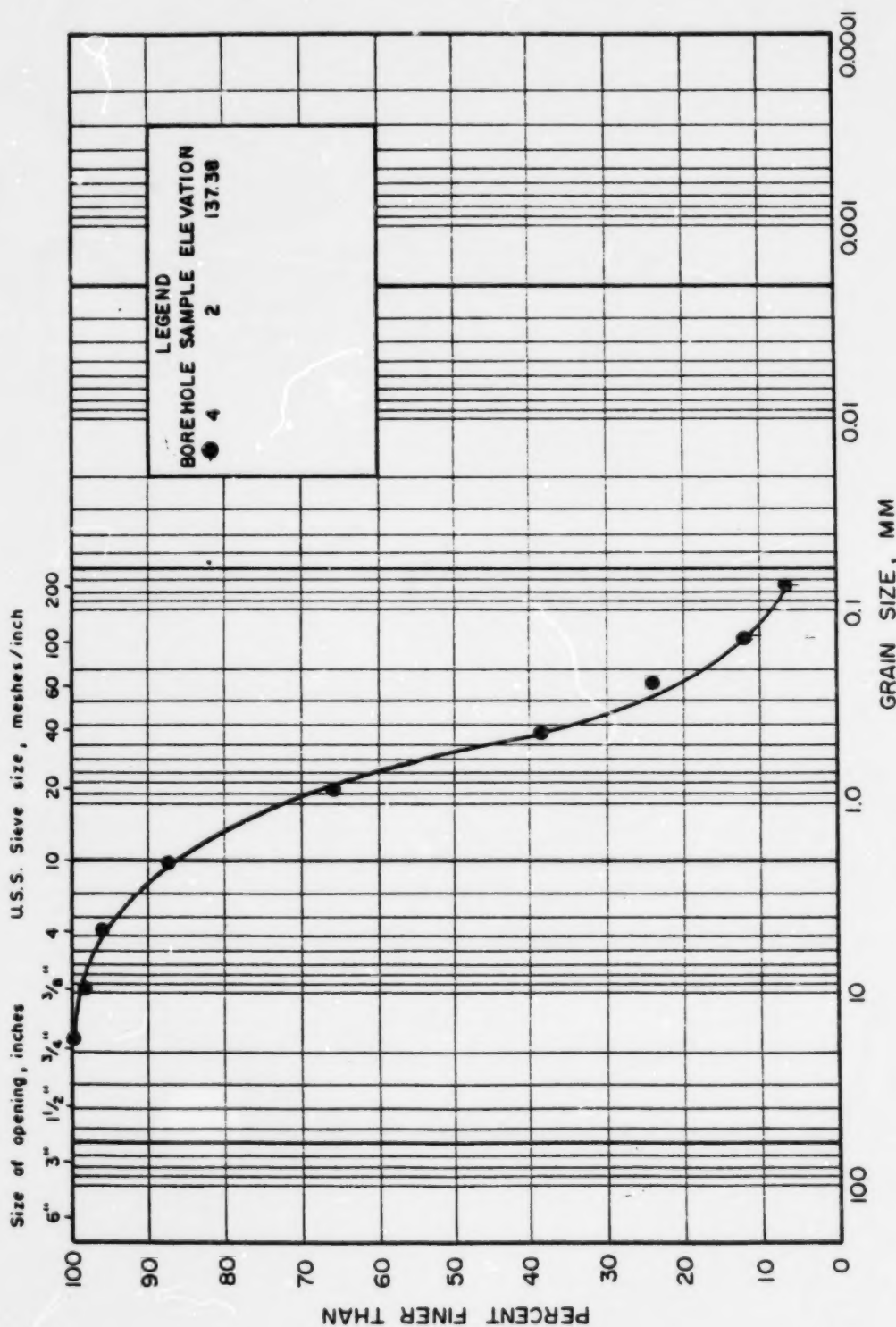
| COBBLE<br>SIZE | COARSE      | MEDIUM | FINE | COARSE    | MEDIUM | FINE | SILT SIZE    | CLAY SIZE |
|----------------|-------------|--------|------|-----------|--------|------|--------------|-----------|
|                | GRAVEL SIZE |        |      | SAND SIZE |        |      | FINE GRAINED |           |

Golder Associates

# GRAIN SIZE DISTRIBUTION ALLUVIUM

FIGURE A-4

M.I.T. GRAIN SIZE SCALE



Golder Associates

### Clay Size Constituents

Semi-quantitative estimates of the mineralogical composition of the  $< 2 \mu\text{m}$  fraction were made by x-ray diffraction of mineral soils recovered from the Portland Creek area.

Sample preparation followed the techniques of Biscaye (1965) and Mehra and Jackson (1959). This involved the removal of silt by settling in the presence of sodium hexametaphosphate and concentration of the  $< 2 \mu\text{m}$  sample induced by calcium chloride, followed by centrifuging. In addition, the samples were subjected to hydrochloric acid and dithionate treatments for the removal of carbonate and fine iron oxides, respectively. Oriented samples were then prepared by filtration onto standard cellulose nitrate filters and mounted on glass slides. Untreated and glycolated samples were run on a Phillips x-ray diffractometer at  $1^\circ 2\theta/\text{min}$ . using Cukoc radiation at 40 kv and 20 ma.

The relative abundances of the major clay minerals were determined by measuring and applying weighting factors to the following peak areas (peak height multiplied by peak width at half height) on the glycolated pattern: the  $17\text{\AA}$  montmorillonite peak; four times the  $10\text{\AA}$  illite peak; and twice the  $7\text{\AA}$  kaolinite plus chlorite peak (Biscaye, 1965). The four weighted peak areas were summed and each expressed as a percentage of the total, as 100 per cent clay minerals. The  $4.26\text{\AA}$ ,  $8.4 - 8.5\text{\AA}$ ,  $3.18\text{\AA}$  and  $2.99\text{\AA}$  peaks were used to quantify quartz, amphibole, feldspar and pyroxene, respectively; these peak areas were calculated as a percentage of the "total clay" peak area using the techniques of Mann and Muller (1980). Less common minerals and mixed layer clays have not been examined in detail. The respective x-ray diffraction curves for the soil samples are shown on Figures A5 and A6.

Of the eight samples studied, only BH1 SA7 and BH4 SA2 (see Record of Boreholes in Appendix A) showed no colour change (i.e. absence of fine iron oxides) upon dithionite treatment.

Bulk mineralogy (100 per cent) and clay mineralogy (100 per cent) values indicated in Table A-1, show no trends with decreasing elevation, or distance from the escarpment. Feldspar is a major constituent of the bulk mineralogy of the <2 um size fraction, denoting a granitic origin. This is especially apparent in samples TP7-3, BH2-6, and BH4-2. Amphiboles (hornblende) pyroxenes were predictably low in quantity throughout the samples.

Clay minerals comprise at least half of the bulk mineralogy of most samples. The low total values for clays in samples TP7-3, BH2-6, TP4-2 and PH4-2 are due in part, to the presence of mixed layer clays which were not analyzed in this study. Of the clays, chlorite and to a lesser extent illite form the dominant assemblages. These minerals are prevalent in regions which have undergone little weathering.

The trace minerals reflect a dominant granitic source (zircon, rutile, apatite) and low degrees of metamorphism (heulandite, clinoptilolite, analcime).

#### References

Biscaye, P.E., 1965. Mineralogy and Sedimentation of Recent Deep-Sea Clay in the Atlantic Ocean and Adjacent Seas and Oceans. Geol. Soc. Am. Bull. 76, pp 803-832.



Mann, U. and Muller G., 1990. X-ray Mineralogy of Deep Sea Drilling Project, Legs 51 through 53, Western North Atlantic. In: T. Donnelly, J. Francheteau et al., Initial Reports of the Deep Sea Drilling Project, v. 51, 52, 53, Part 2. U.S. Govt. Printing Office, Washington, D.C., pp 721-729.

Mehra, O.P. and Jackson, M.L., 1960. Iron Oxide Removal from Soils and Clays by Dithionite-Citrate System Buffered with Sodium Bicarbonate, pp 317-327. In: Swineford, A. (ed.), Proc. 7th Natl. Conference: Clays and Clay Minerals, Pergamon Press, London, 369 pp.

TABLE A-1

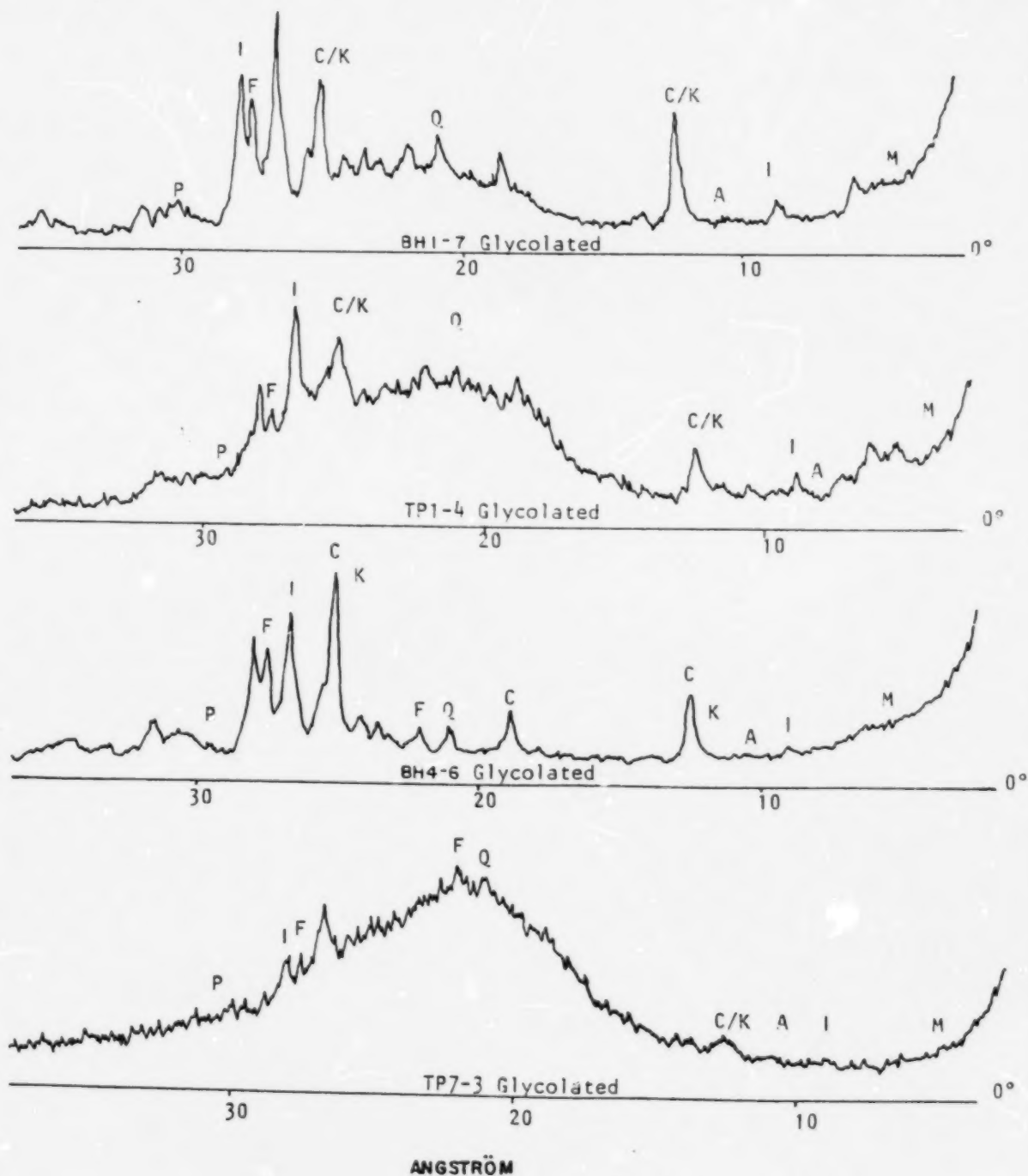
RELATIVE ABUNDANCES OF CLAY-SIZED CONSTITUENTS (%)  
SOIL SAMPLES, PORTLAND CREEK, NEWFOUNDLAND

| SAMPLE | BULK MINERALOGY<br>100% |    |    |    |    | CLAY MINERALOGY<br>100% |    |    |    | TRACE MINERALS                                                      |
|--------|-------------------------|----|----|----|----|-------------------------|----|----|----|---------------------------------------------------------------------|
|        | Clays                   | Q  | A  | F  | P  | M                       | I  | C  | K  |                                                                     |
| BH1-7  | 61                      | 9  | 4  | 25 | 1  | 1                       | 3  | 84 | 8  | Kaolinite, Strontianite                                             |
| TP7-3  | 41                      | 11 | 4  | 40 | 4  | 6                       | 38 | 50 | 6  | Heulandite - Clinoptilolite<br>Serpentine, Analcime, Rutile         |
| TP2-5  | 85                      | 5  | 1  | 8  | 1  | 1                       | 14 | 76 | 9  | Clinoptilolite, Halloysite                                          |
| TP1-4  | 77                      | 8  | 2  | 11 | 2  | 2                       | 36 | 50 | 12 | Zircon, Serpentine, Barite,<br>Apatite                              |
| BH2-6  | 49                      | 5  | 2  | 43 | 1  | 2                       | 5  | 85 | 8  | Analcime                                                            |
| BH3-2  | 52                      | 14 | 11 | 12 | 11 | 17                      | 11 | 67 | 5  | Serpentine, Strontianite,<br>Barite, Heulandite -<br>Clinoptilolite |
| TP4-2  | 50                      | 22 | 3  | 24 | 1  | 6                       | 90 | 4  | tr | Apatite, Analcime                                                   |
| BH4-2  | 38                      | 7  | 7  | 41 | 7  | 9                       | 24 | 37 | 30 | Rutile                                                              |

Q = Quartz      A = Amphiboles      F = Feldspar      P = Pyroxene  
M - Montmorillonite      I = Illite      C = Chlorite      K = Kaolinite

# X-RAY DIFFRACTION CURVES

FIGURE A-5



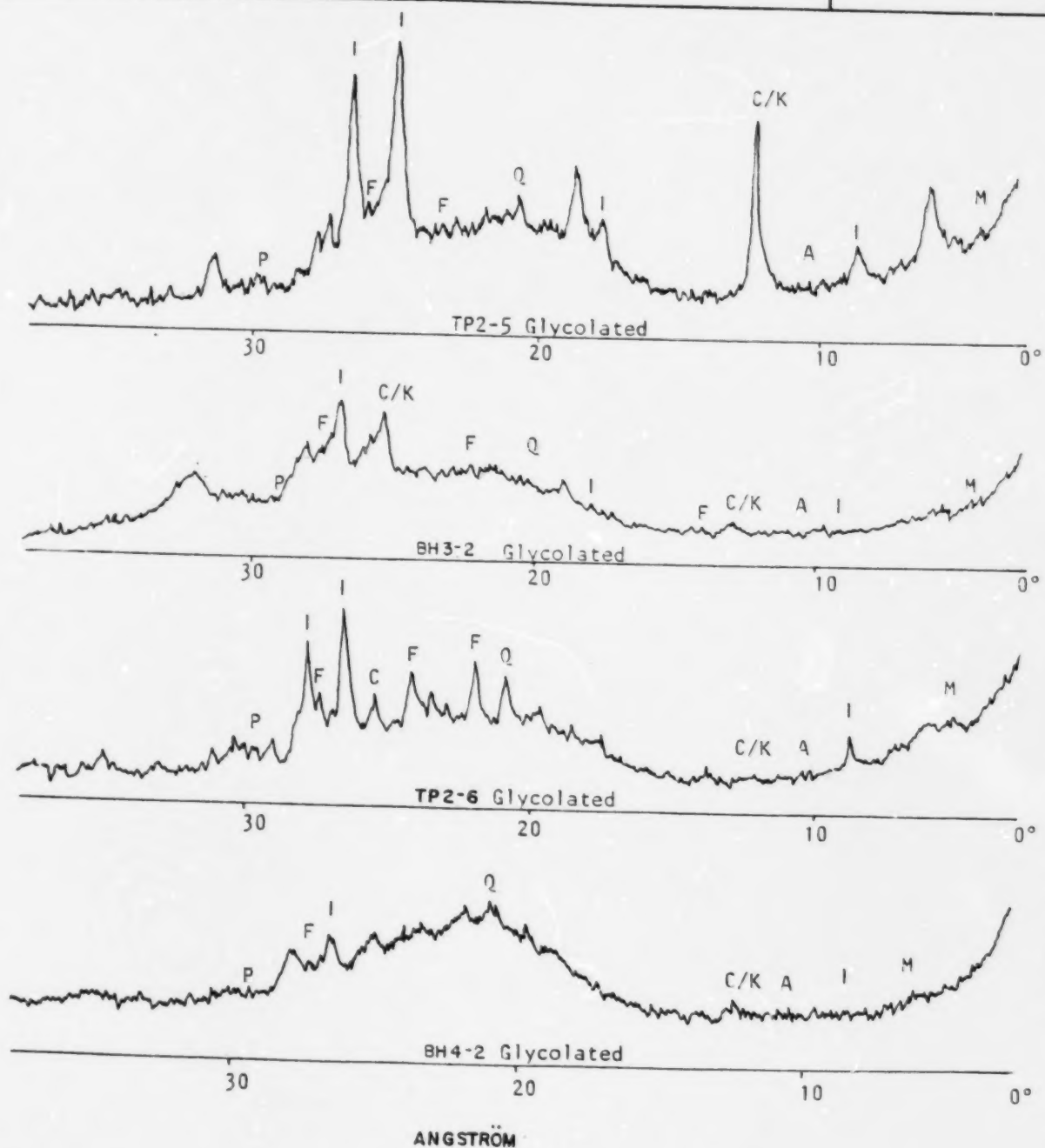
Date FEB. 7, 1985  
Project No. 841-5033

Golder Associates

Drawn L.L.  
Chkd. 3223

# X-RAY DIFFRACTION CURVES

FIGURE A-6



Date FEB. 7, 1985  
Project No. 841-5033

Golder Associates

Drawn L.L.  
Chkd. JDB

APPENDIX B

SOIL AND GROUNDWATER CHEMISTRY



TABLE B-1  
SCHEDULE OF ANALYSES  
SOIL SAMPLES

| MONENCO                                 |                             |      | ANALYTICAL STAGE |   |   |   |   |   |   |
|-----------------------------------------|-----------------------------|------|------------------|---|---|---|---|---|---|
| NO.                                     | FIELD IDENTIFICATION NO.    |      | *                | 1 | 2 | 3 | 4 | 5 | 6 |
| <u>Auger Probe Samples</u>              |                             |      |                  |   |   |   |   |   |   |
| PS4854                                  | L23 + 50N x 10 + 00E (Silt) | A-1  | X                |   |   |   |   |   |   |
| RS4855                                  | L23 + 50N x 10 + 00E (Sand) | "    | X                |   |   |   |   |   |   |
| RS4856                                  | L25 + 00N x 10 + 00E (Silt) | A-2  | X                |   |   |   |   |   |   |
| RS4857                                  | L25 + 00N x 10 + 00E (Sand) | "    | X                |   |   |   |   |   |   |
| RS4858                                  | L25 + 25N x 10 + 00E (Silt) | A-3  | X                |   |   |   |   |   |   |
| RS4859                                  | L25 + 25N x 10 + 00E (Sand) | "    | X                |   |   |   |   |   |   |
| RS4860                                  | L26 + 00N x 8 + 50E (Silt)  | A-4  | X                |   |   |   |   |   |   |
| RS4861                                  | L26 + 00N x 8 + 50E (Sand)  | "    | X                |   |   |   |   |   |   |
| RS4862                                  | L26 + 25N x 9 + 00E (Silt)  | A-5  | X                |   |   |   |   |   |   |
| RS4863                                  | L26 + 25N x 9 + 00E (Sand)  | "    | X                |   |   |   |   |   |   |
| RS4864                                  | L26 + 00N x 9 + 94E (Silt)  | A-6  | X                |   |   |   |   |   |   |
| RS4865                                  | L26 + 00N x 9 + 94E (Sand)  | "    | X                |   |   |   |   |   |   |
| RS4866                                  | L26 + 00N x 9 + 96E (Silt)  | A-7  | X                |   |   |   |   |   |   |
| RS4867                                  | L26 + 00N x 9 + 96E (Sand)  | "    | X                |   |   |   |   |   |   |
| RS4868                                  | L26 + 50N x 9 + 00E (Silt)  | A-8  | X                |   |   |   |   |   |   |
| RS4869                                  | L26 + 50N x 9 + 00E (Sand)  | "    | X                |   |   |   |   |   |   |
| RS4870                                  | L26 + 00N x 9 + 00E (Silt)  | A-9  | X                |   |   |   |   |   |   |
| RS4871                                  | L26 + 00N x 9 + 00E (Sand)  | "    | X                |   |   |   |   |   |   |
| RS4872                                  | L27 + 9 + 00E (Silt)        | A-10 | X                |   |   |   |   |   |   |
| RS4873                                  | L27 + 9 + 00E (Sand)        | "    | X                |   |   |   |   |   |   |
| RS4874                                  | L27 + 75N x 10 + 00E (Silt) | A-11 | X                |   |   |   |   |   |   |
| RS4875                                  | L27 + 75N x 10 + 00E (Sand) | "    | X                |   |   |   |   |   |   |
| RS4876                                  | L29 + 00N x 10 + 00E (Silt) | A-12 | X                |   |   |   |   |   |   |
| RS4877                                  | L29 + 00N x 10 + 00E (Sand) | "    | X                |   |   |   |   |   |   |
| RS4878                                  | L26 + 00N x 8 + 75E (Silt)  | A-13 | X                |   |   |   |   |   |   |
| RS4879                                  | L26 + 00N x 8 + 75E (Sand)  | "    | X                |   |   |   |   |   |   |
| <u>Borehole Samples - Mineral Soils</u> |                             |      |                  |   |   |   |   |   |   |
| RS4587                                  | B1, SA#3 (Silt)             |      | X                |   |   |   |   |   |   |
| RS4588                                  | B1, SA#3 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4589                                  | B1, SA#7 (Silt)             |      | X                |   |   |   |   |   |   |
| RS4590                                  | B1, SA#7 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4591                                  | B2, SA#6 (Silt [coarse])    |      | X                |   |   |   |   |   |   |
| RS4592                                  | B3, SA#2 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4593                                  | B4, SA#2 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4840                                  | B2, SA#6 (Silt)             |      | X                |   |   |   |   |   |   |
| RS4841                                  | B2, SA#6 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4842                                  | B2, SA#6 (Pebbles)          |      | X                |   |   |   |   |   |   |
| RS4843                                  | B3, SA#4 (Silt)             |      | X                |   |   |   |   |   |   |
| RS4844                                  | B3, SA#4 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4845                                  | B3, SA#4 (Pebbles)          |      | X                |   |   |   |   |   |   |
| RS4846                                  | B3, SA#6 (Silt)             |      | X                |   |   |   |   |   |   |
| RS4847                                  | B3, SA#6 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4848                                  | B3, SA#6 (Pebbles)          |      | X                |   |   |   |   |   |   |
| RS4849                                  | B4, SA#2 (Silt)             |      | X                |   |   |   |   |   |   |
| RS4850                                  | B4, SA#2 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4851                                  | B4, SA#3 (Silt)             |      | X                |   |   |   |   |   |   |
| RS4852                                  | B4, SA#3 (Sand)             |      | X                |   |   |   |   |   |   |
| RS4853                                  | B4, SA#3 (Pebbles)          |      | X                |   |   |   |   |   |   |
| <u>Borehole Samples - Organic Soils</u> |                             |      |                  |   |   |   |   |   |   |
| RS4880                                  | B1, SA#1                    |      | X                |   |   |   |   |   |   |
| PS4881                                  | B1, SA#2                    |      | X                |   |   |   |   |   |   |
| RS4882                                  | B1A, SA#4                   |      | X                |   |   |   |   |   |   |
| RS4883                                  | B2, SA#1                    |      | X                |   |   |   |   |   |   |
| RS4884                                  | B2, SA#2                    |      | X                |   |   |   |   |   |   |
| RS4885                                  | B2, SA#3                    |      | X                |   |   |   |   |   |   |
| RS4886                                  | B3, SA#1                    |      | X                |   |   |   |   |   |   |

\* Sample location reference shown on Figure 1.

TABLE B-1 (cont'd)

SCHEDULE OF ANALYSES  
SOIL SAMPLES

| MONENCO<br>NO.                          | FIELD IDENTIFICATION NO. | ANALYTICAL STAGE |   |   |   |   |   |
|-----------------------------------------|--------------------------|------------------|---|---|---|---|---|
|                                         |                          | 1                | 2 | 3 | 4 | 5 | 6 |
| <u>Test Pit Samples - Mineral Soils</u> |                          |                  |   |   |   |   |   |
| RS4594                                  | TP1, SA#6 (Silt)         | X                |   |   |   |   |   |
| RS4595                                  | TP1, SA#6 (Sand)         | X                |   |   |   |   |   |
| RS4596                                  | TP2, SA#1 (Silt)         | X                |   |   |   |   |   |
| RS4597                                  | TP2, SA#1 (Sand)         | X                |   |   |   |   |   |
| RS4598                                  | TP2, SA#5 (Sand)         | X                |   |   |   |   |   |
| RS4599                                  | TP3, SA#1 (Silt)         | X                |   |   |   |   |   |
| RS4600                                  | TP3, SA#1 (Sand)         | X                |   |   |   |   |   |
| RS4601                                  | TP3, SA#2 (Silt)         | X                | X |   |   |   |   |
| RS4602                                  | TP3, SA#2 (Sand)         | X                | X |   |   |   |   |
| RS4603                                  | TP4, SA#2 (Silt)         | X                | X |   |   |   |   |
| RS4604                                  | TP4, SA#2 (Sand [Rocks]) | X                |   |   |   |   |   |
| RS4605                                  | TP4, SA#3 (Silt)         | X                |   |   |   |   |   |
| RS4606                                  | TP5, SA#8 (Silt)         | X                | X | X |   |   |   |
| RS4607                                  | TP5, SA#8 (Sand)         | X                | X | X |   |   |   |
| RS4608                                  | TP7, SA#3 (Sand)         | X                |   |   |   |   |   |
| RS4609                                  | TP7, SA#3 (Rocks)        | X                |   |   |   |   |   |
| <u>Test Pit Samples - Organic Soils</u> |                          |                  |   |   |   |   |   |
| RS4610                                  | TP1, SA#1                | X                |   |   |   |   |   |
| RS4611                                  | TP1, SA#2                | X                | X |   |   |   |   |
| RS4612                                  | TP1, SA#3                | X                |   |   |   |   |   |
| RS4613                                  | TP1, SA#5                | X                |   |   |   |   |   |
| RS4614                                  | TP2, SA#2                | X                |   |   |   |   |   |
| RS4615                                  | TP2, SA#3                | X                |   |   |   |   |   |
| RS4616                                  | TP2, SA#4                | X                |   |   |   |   |   |
| RS4617                                  | TP3, SA#3                | X                |   |   |   |   |   |
| RS4618                                  | TP3, SA#4                | X                |   |   |   |   |   |
| RS4619                                  | TP3, SA#5                | X                |   |   |   |   |   |
| RS4620                                  | TP4, SA#1                |                  | X |   |   |   |   |
| RS4621                                  | TP5, SA#1                | X                | X | X |   |   |   |
| RS4622                                  | TP5, SA#2                | X                |   |   |   |   |   |
| RS4623                                  | TP5, SA#3                | X                |   |   |   |   |   |
| RS4624                                  | TP5, SA#4                | X                | X | X | X | X |   |
| RS4625                                  | TP5, SA#5                | X                |   |   |   |   |   |
| RS4626                                  | TP5, SA#6                | X                |   |   |   |   |   |
| RS4627                                  | TP5, SA#7                | X                | X | X |   |   |   |
| RS4887                                  | TP10, SA#1               | X                | X | X | X |   |   |
| RS4888                                  | TP10, SA#2               | X                | X |   |   |   |   |
| RS4889                                  | TP10, SA#3               | X                |   |   |   |   |   |
| RS4890                                  | TP10, SA#4               | X                | X | X | X | X |   |
| RS4891                                  | TP10, SA#5               | X                |   |   |   |   |   |
| RS4892                                  | TP10, SA#6               | X                |   |   |   |   |   |
| RS4893                                  | TP10, SA#7               | X                | X | X | X | X |   |
| RS4894                                  | TP9, SA#1                | X                | X |   |   |   |   |
| RS4895                                  | TP9, SA#2                | X                |   |   |   |   |   |
| RS4896                                  | TP9, SA#3                | X                | X |   |   |   |   |
| RS4897                                  | TP8, SA#1                | X                | X | X |   |   |   |
| RS4898                                  | TP8, SA#2                | X                |   |   |   |   |   |
| RS4899                                  | TP8, SA#3                | X                |   |   |   |   |   |
| RS4900                                  | TP8, SA#4                | X                | X | X |   |   |   |
| RS4901                                  | TP7, SA#1                | X                | X |   |   |   |   |
| RS4902                                  | TP7, SA#4                | X                |   |   |   |   |   |
| RS4903                                  | TP6, SA#1                | X                |   |   |   |   |   |
| RS4904                                  | TP6, SA#2                | X                | X |   |   |   |   |
| RS4905                                  | TP6, SA#3                | X                |   |   |   |   |   |

Parameters Analyzed in each Stage of Analysis

Stage 1 - total uranium

Stage 2 - TKN, total S, Fe, Mn, Cu, Pb, Zn, Ni, As, Th, equivalent CaCO<sub>3</sub>

Stage 3 - total thorium-230, total radium-226

Stage 4 - uranium-234/uranium-238 activity ratio

Stage 5 - uranium-235, protactinium-231, lead-210, polonium-210

TABLE B-2

SCHEDULE OF ANALYSESGROUNDWATER SAMPLES

| MONENCO<br>NO. | SAMPLE FIELD<br>IDENTIFICATION | ANALYTICAL STAGE |   |   |   |   |   |
|----------------|--------------------------------|------------------|---|---|---|---|---|
|                |                                | 1                | 2 | 3 | 4 | 5 | 6 |
| 5369           | P1-1                           | X                | X | X |   |   | X |
| 5370           | P1-2                           | X                | X | X |   |   | X |
| 5360           | P1-3                           | X                | X | X | X | X |   |
| 5371           | P2-1                           | X                | X | X |   |   |   |
| 5361           | P2-2                           | X                | X | X |   |   |   |
| 5362           | P3-1                           | X                | X | X |   |   | X |
| 5363           | P4-1                           | X                | X | X | X | X | X |
| 5373           | TP-1                           | X                | X | X | X | X |   |
| 5359           | TP-5                           | X                | X | X | X | X | X |
|                | TP-8                           |                  |   |   |   |   | X |
| 5372           | TP-10                          | X                | X | X |   |   | X |
| 5367           | TP-28N + 11E                   | X                | X | X |   |   | X |

NOTE: Stage 6 analyses provided by Division of Clinical Chemistry  
Victoria General Hospital, Halifax, Nova Scotia

Parameters Analyzed in each Stage of Analysis

Stage 1 - total uranium, pH, alkalinity, hardness, T.D.S.

Stage 2 - Na,K,Ca,Mg,Cl,SO<sub>4</sub>, PO<sub>4</sub>,Fe,Mn,Cu,Pb,Zn,Ni,As

Stage 3 - total thorium-230, total radium-226

Stage 4 - uranium-234/uranium-238 activity ratio

Stage 5 - uranium-235,protactinium-231, lead-210, polonium-210

Stage 6 - radon-222



TABLE B-4

## SOIL CHEMISTRY - URANIUM

**MONENCO ANALYTICAL LABORATORIES**

#2-2023-2nd Avenue S.E., Calgary, Alta T2E 6K1

November 23, 1984

Rob Blair

Golder Associates

Soils Stage I Samples - Portland Creek - NewfoundlandMineral Soils

| <u>Monenco No.</u> | <u>Identification</u>  | <u>Uranium<br/>ppm dry</u> |
|--------------------|------------------------|----------------------------|
| RS4587             | Bl.SA#3-Silt *         | 2150.                      |
| RS4588             | Bl.SA#3-Sand *         | No sample                  |
| RS4589             | Bl.SA#7-Silt *         | 67.8                       |
| RS4590             | Bl.SA#7-Sand *         | 20.5                       |
| RS4591             | B2,SA#6-Silt *(Coarse) | 49.6                       |
| RS4592             | B3,SA#2-Sand *         | 7.7                        |
| RS4593             | B4,SA#2-Sand           | 13.3                       |
| RS4594             | TP1,SA#6-Silt          | 1010.                      |
| RS4595             | TP1,SA#6-Sand          | 129.                       |
| RS4596             | TP2,SA#1-Silt          | 841.                       |
| RS4597             | TP2,SA#1-Sand          | 93.7                       |
| RS4598             | TP2,SA#5-Sand          | 85.0                       |
| RS4599             | TP3,SA#1-Silt          | 115.                       |
| RS4600             | TP3,SA#1-Sand          | 23.6                       |
| RS4601             | TP3,SA#2-Silt          | 64.8                       |
| RS4602             | TS3,SA#2-Sand          | 24.2                       |
| RS4603             | TP4,SA#2-Silt          | 13.0                       |
| RS4604             | TP4,SA#2-Sand(Rocks)   | 6.9                        |
| RS4605             | TP4,SA#3-Silt          | 29.0                       |
| RS4606             | TP5,SA#8-Silt          | 1490.                      |
| RS4607             | TP5,SA#8-Sand          | 246.                       |
| RS4608             | TP7,SA#3-Sand          | 11.6                       |
| RS4609             | TP7,SA#3-Rocks         | 5.5                        |

Organic Soils

|        |          |        |
|--------|----------|--------|
| RS4610 | TP1,SA#1 | 5950.  |
| RS4611 | TP1,SA#2 | 7780.  |
| RS4612 | TP1,SA#3 | 4800.  |
| RS4613 | TP1,SA#5 | 332.   |
| RS4614 | TP2,SA#2 | 222.   |
| RS4615 | TP2,SA#3 | 665.   |
| RS4616 | TP2,SA#4 | 4140.  |
| RS4617 | TP3,SA#3 | 287.   |
| RS4618 | TP3,SA#4 | 1510.  |
| RS4619 | TP3,SA#5 | 1000.  |
| RS4620 | TP4,SA#1 | 2.5    |
| RS4621 | TP5,SA#1 | 5320.  |
| RS4622 | TP5,SA#2 | 8900.  |
| RS4623 | TP5,SA#3 | 15200. |
| RS4624 | TP5,SA#4 | 17700. |
| RS4625 | TP5,SA#5 | 16700. |
| RS4626 | TP5,SA#6 | 14200. |
| RS4627 | TP5,SA#7 | 16500. |

\* B1, B2, B3, B4 are the same as  
BH1, BH2, BH3 and BH4 in text.



TABLE E-4 (cont'd)

## SOIL CHEMISTRY - URANIUM

**MONENCO ANALYTICAL LABORATORIES**

#2-2023-2nd Avenue S.E., Calgary, Alta T2E 6K1

December 7, 1984

Rob Blair

Golder Associates

Soil Stage 1 Samples - Portland Creek - Newfoundland  
 (2nd batch, received November 21, 1984)

(Mineral Soil)

| Monenco No. | Identification                   | Uranium<br>ppm dry |
|-------------|----------------------------------|--------------------|
| RS4840      | B2 SA #6 (Silt)                  | 168.               |
| RS4841      | B2 SA #6 (Sand)                  | 34.9               |
| RS4842      | B2 SA #6 (Pebbles)               | 7.7                |
| RS4843      | B3 SA #4 (Silt)                  | 45.0               |
| RS4844      | B3 SA #4 (Sand)                  | 8.5                |
| RS4845      | B3 SA #4 (Pebbles)               | 7.0                |
| RS4846      | B3 SA #6 (Silt)                  | 80.5               |
| RS4847      | B3 SA #6 (Sand)                  | 15.6               |
| RS4848      | B3 SA #6 (Pebbles)               | 12.0               |
| RS4849      | B4 SA #2 (Silt)                  | 188.               |
| RS4850      | B4 SA #2 (Sand)                  | 10.9               |
| RS4851      | B4 SA #3 (Silt)                  | 403.               |
| RS4852      | B4 SA #3 (Sand)                  | 54.3               |
| RS4853      | B4 SA #3 (Pebbles)               | 10.1               |
| RS4854      | *A-1 L23 + 50N x 10 + 00E (Silt) | 5680.              |
| RS4855      | A-1 L23 + 50N x 10 + 00E (Sand)  | 173.               |
| RS4856      | A-2 L25 + 00N x 10 + 00E (Silt)  | 5100.              |
| RS4857      | A-2 L25 + 00N x 10 + 00E (Sand)  | 471.               |
| RS4858      | A-3 L25 + 25N x 10 + 00E (Silt)  | 2200.              |
| RS4859      | A-3 L25 + 25N x 10 + 00E (Sand)  | 80.7               |
| RS4860      | A-4 L26 + 00N x 8 + 50E (Silt)   | 1180.              |
| RS4861      | A-4 L26 + 00N x 8 + 50E (Sand)   | 129.               |
| RS4862      | A-5 L26 + 25N x 9 + 00E (Silt)   | 1680.              |
| RS4863      | A-5 L26 + 25N x 9 + 00E (Sand)   | 132.               |
| RS4864      | A-6 L26 + 00N x 9 + 94E (Silt)   | 10.8               |
| RS4865      | A-6 L26 + 00N x 9 + 94E (Sand)   | 4.5                |
| RS4866      | A-7 L26 + 00N x 9 + 96E (Silt)   | 123.               |
| RS4867      | A-7 L26 + 00N x 9 + 96E (Sand)   | 19.4               |
| RS4868      | A-8 L26 + 50N x 9 + 00E (Silt)   | 2390.              |
| RS4869      | A-8 L26 + 50N x 9 + 00E (Sand)   | 219.               |
| RS4870      | A-9 L26 + 00N x 9 + 00E (Silt)   | 3500.              |
| RS4871      | A-9 L26 + 00N x 9 + 00E (Sand)   | 117.               |
| RS4872      | A-10 L27 + 9 + 00E (Silt)        | 2060.              |
| RS4873      | A-10 L27 + 9 + 00E (Sand)        | 62.4               |
| RS4874      | A-11 L27 + 75N x 10 + 00E (Silt) | 641.               |
| RS4875      | A-11 L27 + 75N x 10 + 00E (Sand) | 262.               |
| RS4876      | A-12 L29 + 00N x 10 + 00E (Silt) | 413.               |
| RS4877      | A-12 L29 + 00N x 10 + 00E (Sand) | 47.1               |
| RS4878      | A-13 L26 + 00N x 8 + 75E (Silt)  | 1460.              |
| RS4879      | A-13 L26 + 00N x 8 + 75E (Sand)  | 109.               |

\*Sample locations shown on Figure 4

TABLE B-4 (cont'd)



SOIL CHEMISTRY - URANIUM  
**MONENCO ANALYTICAL LABORATORIES**  
 #2-2023-2nd Avenue S.E., Calgary, Alta T2E 6K1

December 7, 1984  
 Rob Blair  
 Golder Associates  
 Page 2

Soil Stage 1 Samples - Portland Creek - Newfoundland  
 (2nd batch, received November 21, 1984)

(Organic Soil)

| <u>Monenco No.</u> | <u>Identification</u> | <u>Uranium</u><br><u>ppm dry</u> |
|--------------------|-----------------------|----------------------------------|
| RS4880             | B1 SA #1              | 14800.                           |
| RS4881             | B1 SA #2              | 24500.                           |
| RS4882             | B1A SA #4             | 89.1                             |
| RS4883             | B2 SA #1              | 1770.                            |
| RS4884             | B2 SA #2              | 1520.                            |
| RS4885             | B2 SA #3              | 1580.                            |
| RS4886             | B3 SA #1              | 70.2                             |
| RS4887             | TP #10-SA #1          | 2980.                            |
| RS4888             | TP #10-SA #2          | 10400.                           |
| RS4889             | TP #10-SA #3          | 16000.                           |
| RS4890             | TP #10-SA #4          | 21200.                           |
| RS4891             | TP #10-SA #5          | 28100.                           |
| RS4892             | TP #10-SA #6          | 25000.                           |
| RS4893             | TP #10-SA #7          | 27800.                           |
| RS4894             | TP #9-SA #1           | 5770.                            |
| RS4895             | TP #9-SA #2           | 16200.                           |
| RS4896             | TP #9-SA #3           | 18900.                           |
| RS4897             | TP #8-SA #1           | 255.                             |
| RS4898             | TP #8-SA #2           | 1210.                            |
| RS4899             | TP #8-SA #3           | 5070.                            |
| RS4900             | TP #8-SA #4           | 22800.                           |
| RS4901             | TP #7-SA #1           | 6.6                              |
| RS4902             | TP #7-SA #4           | 2660.                            |
| RS4903             | TP #6-SA #1           | 192.                             |
| RS4904             | TP #6-SA #2           | 1200.                            |
| RS4905             | TP #6-SA #3           | 1730.                            |

TABLE B-5

## GROUNDWATER CHEMISTRY

## MAJOR ELEMENTS AND RADIONUCLIDES

|                                 | P1-1   | P1-2   | P1-3   | P2-1   | P2-2   | P3-1   | P4-1   | TP-1   | TP-5   | TP-10  | TP-29N+11E |
|---------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|------------|
| pH                              | 6.06   | 6.16   | 6.04   | 6.20   | 5.69   | 5.72   | 6.21   | 4.87   | 5.16   | 6.28   | 5.72       |
| Alk-T (CaCO <sub>3</sub> )      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0          |
| Alk-P (CaCO <sub>3</sub> )      | 20     | 26     | 32     | 16     | 16     | 35     | 14     | 9      | 8      | 15     | 10         |
| Carb. (CO <sub>3</sub> )        | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0          |
| Bicarbonate (HCO <sub>3</sub> ) | 24     | 32     | 39     | 19     | 19     | 42     | 17     | 11     | 10     | 18     | 12         |
| Hydroxide (OH)                  | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0          |
| Hardness (CaCO <sub>3</sub> )   | 18     | 15     | 2      | 16     | 6      | 23     | 11     | 8      | 9      | 14     | 10         |
| Conductivity                    | 60     | 69     | 80     | 51     | 64     | 93     | 47     | 40.2   | 43     | 45.8   | 39         |
| T.D.S.                          | 52     | 64     | 92     | 54     | 124    | 138    | 52     | 78     | 74     | 46     | 30         |
| Ca                              | 5.3    | 4.5    | <0.7   | 4.3    | 1.0    | 4.2    | 3.2    | 2.1    | 2.6    | 4.0    | 2.6        |
| Mg                              | <0.1   | <0.1   | <0.1   | <0.1   | <0.1   | 1.2    | <0.1   | <0.1   | <0.1   | <0.1   | <0.1       |
| Na                              | 3.5    | 8.1    | 19.6   | 2.3    | 12.4   | 12.2   | 3.7    | 4.0    | 4.9    | 2.5    | 3.0        |
| K                               | <0.2   | <0.2   | 1.5    | <0.2   | 1.2    | 1.8    | 1.3    | 0.2    | 1.3    | <0.2   | 1.0        |
| SO <sub>4</sub>                 | 3.4    | 4.3    | 6.6    | 3.0    | 4.4    | 5.0    | 3.1    | 1.5    | 2.3    | 2.8    | 3.3        |
| Cl                              | 6.1    | 5.0    | 6.0    | 5.0    | 7.1    | 6.0    | 4.2    | 5.7    | 6.3    | 4.4    | 5.0        |
| Phosphate-Ortho                 | <0.01  | <0.01  | 0.02   | <0.01  | 0.09   | 0.02   | 0.01   | <0.01  | 0.06   | <0.01  | <0.01      |
| As                              | <0.01  | <0.01  | <0.01  | <0.01  | <0.01  | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010     |
| Cu                              | <0.016 | <0.016 | <0.016 | <0.016 | <0.016 | <0.016 | <0.016 | <0.016 | <0.016 | <0.016 | <0.016     |
| Fe                              | 0.053  | 0.812  | 0.359  | 0.179  | 0.473  | 5.940  | 0.666  | 0.717  | 0.861  | 0.042  | 0.013      |
| Mn                              | 0.015  | 0.128  | 0.005  | 0.037  | 0.023  | 0.160  | 0.160  | 0.011  | 0.013  | 0.002  | 0.002      |
| Ni                              | <0.01  | 0.02   | <0.01  | <0.01  | <0.01  | <0.01  | <0.01  | 0.02   | <0.01  | 0.02   | <0.01      |
| Pb                              | 0.05   | <0.01  | <0.01  | <0.01  | <0.01  | <0.01  | <0.01  | <0.01  | <0.01  | 0.04   | <0.01      |
| U                               | 0.0360 | 0.0680 | 0.4150 | 0.0540 | 0.235  | 0.0905 | 0.2450 | 0.420  | 0.715  | 0.0475 | 0.0295     |
| Zn                              | 0.053  | 0.036  | 0.116  | 0.021  | 0.126  | 0.091  | 0.226  | 0.219  | 0.045  | 0.007  | 0.007      |
| Ra-226                          | 0.007  | 0.020  | 0.067  | 0.019  | 0.015  | 0.096  | 0.241  | 0.062  | 0.190  | 0.032  | 0.006      |
|                                 | <0.001 | <0.003 | <0.014 | <0.006 | <0.006 | <0.016 | <0.016 | <0.016 | <0.005 | <0.011 | <0.003     |
| Thorium-230                     | <0.005 | <0.005 | 0.017  | <0.005 | 0.017  | 0.088  | 0.212  | 0.116  | 0.145  | 0.006  | 0.006      |
|                                 |        |        | <0.006 |        | <0.009 | <0.014 | <0.014 | <0.015 | <0.004 | <0.003 | <0.002     |
| Charge Balance                  | -20.8  | -10.3  | -3.2   | -4.5   | -3.2   | -6.3   | -10.7  | -10.4  | -2.5   | -21.6  | -17.1      |

# MONENCO ANALYTICAL LABORATORIES

Rob Blair  
Golder Associates  
March 12, 1985

TABLE B-5 (cont'd)

| Monenco<br>No. | I.D. | U<br>mg/L | <u>U<sup>234</sup>/U<sup>238</sup></u> | U-235     | Pa-231 | (as of Feb 19) |           |
|----------------|------|-----------|----------------------------------------|-----------|--------|----------------|-----------|
|                |      |           |                                        |           |        | Pb-210         | Po-210    |
|                |      |           |                                        |           |        | -----BQ/L----- |           |
| 5359           | TP-5 | 715       | 1.03±0.05                              | 0.41±0.05 | <0.005 | 1.32±0.11      | 0.79±0.20 |
| 5360           | P1-3 | 415       | 1.20±0.05                              | 0.23±0.05 | <0.005 | 0.68±0.06      | 0.34±0.09 |
| 5363           | P4-1 | 245       | 1.04±0.05                              | 0.13±0.05 | <0.005 | 1.15±0.10      | 0.74±0.08 |
| 5373           | TP-1 | 620       | 1.37±0.05                              | 0.34±0.05 | <0.005 | 0.42±0.04      | 0.24±0.05 |

APPENDIX C

SURFACE WATER AND STREAM

SEDIMENT CHEMISTRY



TABLE C-1

## Surface Water Quality Monitoring Program

| <u>Station Name</u> | <u>Sample Dates</u> | <u>Stage 2</u> | <u>Stage 3</u> | <u>Stage 4</u> | <u>Stage 5</u> | <u>Stage 6</u> |
|---------------------|---------------------|----------------|----------------|----------------|----------------|----------------|
| Spring L28N         | 22 & 26 Aug         | C              | C              | C              | none           | S              |
| Creek L28N          | 22 & 28 Aug         | C              | C              | C              | none           |                |
| Creek L24N          |                     |                |                |                |                |                |
| Station #1          | 22 & 28 Aug         | C              | C              | C              | none           | S              |
| Station #2          | 22 & 27 Aug         | C              | S              | C              | C              | S              |
| Brucy Brook         |                     |                |                |                |                |                |
| East                | 23 & 27 Aug         | C              | C              | none           | C              |                |
| West                | 26 & 28 Aug         | C              | none           | none           | none           |                |
| Mouth               | 23 & 27 Aug         | C              | C              | none           | none           |                |
| Falls Lake          |                     |                |                |                |                |                |
| Centre              | 26 & 29 Aug         | C              | none           | none           | none           |                |
| Outlet              | 23 & 27 Aug         | C              | S              | C              | C              |                |
| Suitcase Lake       |                     |                |                |                |                |                |
| Outlet              | 26 & 29 Aug         | C              | C              | none           | none           |                |

Notes

C - composite of the samples gathered on the two dates

S - each sample analyzed separately

All samples were measured for pH and temperature in the field.

TABLE C-1 (continued)

In Stage 1, all samples were analyzed for: pH, alkalinity, carbonate, bicarbonate, hydroxide, hardness, total dissolved solids (TDS) and total uranium.

Stage 2: major cations and anions, iron, manganese, copper, lead, nickel and zinc

Stage 3: total thorium-230 and total radium-226

Stage 4: uranium-234/uranium-238 activity ratio

Stage 5: uranium-235, protactinium-231, lead-210 and polonium-210

Stage 6: radon-222

TABLE C-2

## Stream Sediment Quality Monitoring Program

| <u>Station Name</u> | <u>Sample Date</u> | <u>Stage 2</u> | <u>Stage 3</u> | <u>Stage 4</u> | <u>Stage 5</u> |
|---------------------|--------------------|----------------|----------------|----------------|----------------|
| Spring L28N         | 22 Aug             | X              | X              | X              | X              |
| Creek L28N          | 22 Aug             | -              | -              | -              | -              |
| Creek L24N          |                    |                |                |                |                |
| Station #1          | 22 Aug             | -              | X              | X              | X              |
| Special             | 27 Aug             | X              | -              | X              | -              |
| Station #2          | 22 Aug             | X              | X              | X              | -              |
| Big Rock Pond       | 28 Aug             | -              | X              | X              | -              |
| Brucy Brook         |                    |                |                |                |                |
| East                | 23 Aug             | X              | X              | -              | -              |
| East Special        | 27 Aug             | -              | -              | -              | -              |
| West                | 26 Aug             | X              | -              | -              | -              |
| West Special        | 27 Aug             | -              | -              | -              | -              |
| Main Special        | 28 Aug             | -              | -              | -              | -              |
| Mouth               | 23 Aug             | X              | X              | -              | -              |
| Falls Lake          |                    |                |                |                |                |
| Centre              | 26 Aug             | X              | X              | X              | -              |
| Outlet              | 23 Aug             | X              | X              | -              | -              |
| Special #1          | 27 Aug             | -              | -              | -              | -              |
| Special #2          | 27 Aug             | -              | -              | -              | -              |
| Special #3          | 27 Aug             | X              | X              | -              | -              |
| Special #4          | 27 Aug             | -              | -              | -              | -              |
| Special #5          | 27 Aug             | -              | -              | -              | -              |

TABLE C-2 (continued)

| <u>Station Name</u>     | <u>Sample Date</u> | <u>Stage 2</u> | <u>Stage 3</u> | <u>Stage 4</u> | <u>Stage 5</u> |
|-------------------------|--------------------|----------------|----------------|----------------|----------------|
| Suitcase Lake<br>Outlet | 26 Aug             | X              | X              | -              | X              |

Notes

X - analysis performed

All samples were analyzed for uranium in Stage 1.

Stage 2: total Kjeldahl nitrogen, total sulfur, calcium carbonate equivalent, arsenic, copper, iron, manganese, nickel, lead, thorium and zinc

Stage 3: thorium-230 and radium-226

Stage 4: uranium-234/uranium-238 activity ratio

Stage 5: uranium-235, protactinium-231, lead-210 and polonium-210

TABLE C-3

SURFACE WATER CHEMISTRY  
MAJOR ELEMENTS AND RADIONUCLIDES

| Station             | Field temp<br>(°F) | Field pH | Temp pH | alkalinity-P<br>(mg/L CaCO <sub>3</sub> ) | alkalinity-T carbonate<br>(mg/L CaCO <sub>3</sub> ) | bicarbonate<br>(mg/L HCO <sub>3</sub> <sup>-</sup> ) | hydroxide<br>(mg/L OH <sup>-</sup> ) | hardness<br>(mg/L CaCO <sub>3</sub> ) | TDS<br>(mg/L) | calcium<br>(mg/L) | magnesium<br>(mg/L) | sodium<br>(mg/L) | potassium<br>(mg/L) | sulfate<br>(mg/L) | chloride<br>(mg/L) | phosphate ±0<br>(mg/L-P) |
|---------------------|--------------------|----------|---------|-------------------------------------------|-----------------------------------------------------|------------------------------------------------------|--------------------------------------|---------------------------------------|---------------|-------------------|---------------------|------------------|---------------------|-------------------|--------------------|--------------------------|
| Spring L28N -22 Aug | 44                 | 5.85     | 5.66    | 0                                         | 12                                                  | 0                                                    | 15                                   | 0                                     | 13            | 26                | -                   | -                | -                   | -                 | -                  | -                        |
| -26 Aug             | 44                 | 5.85     | 5.72    | 0                                         | 10                                                  | 0                                                    | 12                                   | 0                                     | 11            | 46                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Crack L28N -22 Aug  | 56                 | 5.40     | 5.32    | 0                                         | 8                                                   | 0                                                    | 10                                   | 0                                     | 12            | 32                | -                   | -                | -                   | -                 | -                  | -                        |
| -26 Aug             | 57                 | 5.80     | 5.77    | 0                                         | 8                                                   | 0                                                    | 10                                   | 0                                     | 11            | 56                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Crack L28N -22 Aug  | 47                 | 5.75     | 5.66    | 0                                         | 15                                                  | 0                                                    | 18                                   | 0                                     | 18            | 34                | -                   | -                | -                   | -                 | -                  | -                        |
| Station #1 -26 Aug  | 48                 | 5.65     | 5.93    | 0                                         | 15                                                  | 0                                                    | 18                                   | 0                                     | 16            | 56                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Crack L28N -22 Aug  | 52                 | 5.55     | 6.02    | 0                                         | 14                                                  | 0                                                    | 17                                   | 0                                     | 16            | 36                | -                   | -                | -                   | -                 | -                  | -                        |
| Station #2 -27 Aug  | 54                 | 5.70     | 6.29    | 0                                         | 14                                                  | 0                                                    | 17                                   | 0                                     | 21            | 46                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Brucy Brook -23 Aug | 58                 | 5.10     | 5.44    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 3             | 32                | -                   | -                | -                   | -                 | -                  | -                        |
| East -27 Aug        | 57                 | 5.95     | 5.99    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 3             | 40                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Brucy Brook -26 Aug | 56                 | 4.40     | 5.49    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 3             | 40                | -                   | -                | -                   | -                 | -                  | -                        |
| West -26 Aug        | 57                 | 4.55     | 5.51    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 3             | 30                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Brucy Brook -23 Aug | 59                 | 5.55     | 5.67    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 3             | 26                | -                   | -                | -                   | -                 | -                  | -                        |
| Mouth -27 Aug       | 60                 | 5.65     | 6.14    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 3             | 34                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Falls Lake -26 Aug  | 56                 | 5.80     | 5.72    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 10            | 34                | -                   | -                | -                   | -                 | -                  | -                        |
| Centre -29 Aug      | 61                 | 5.70     | 5.80    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 4             | 26                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Falls Lake -23 Aug  | 60                 | 4.95     | 5.65    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 6             | 14                | -                   | -                | -                   | -                 | -                  | -                        |
| Outlet -27 Aug      | 60                 | 5.75     | 5.87    | 0                                         | 4                                                   | 0                                                    | 5                                    | 0                                     | 4             | 32                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
| Sullivan L. -26 Aug | 59                 | 6.65     | 6.31    | 0                                         | 12                                                  | 0                                                    | 15                                   | 0                                     | 14            | 30                | -                   | -                | -                   | -                 | -                  | -                        |
| Outlet -29 Aug      | 61                 | 6.65     | 6.68    | 0                                         | 12                                                  | 0                                                    | 15                                   | 0                                     | 13            | 36                | -                   | -                | -                   | -                 | -                  | -                        |
| -Comp.              | -                  | -        | -       | -                                         | -                                                   | -                                                    | -                                    | -                                     | -             | -                 | -                   | -                | -                   | -                 | -                  | -                        |
|                     |                    |          |         |                                           |                                                     |                                                      |                                      |                                       |               |                   | 1.9                 | 40.05            | 1.6                 | 0.2               | 3.0                | 5.7                      |



TABLE C-3 (cont'd)

SURFACE WATER CHEMISTRY  
MAJOR ELEMENTS AND RADIONUCLIDES

| Station                         | arsenic<br>(ug/L) | copper<br>(ug) | iron<br>(mg/L) | manganese<br>(mg/L) | nickel<br>(mg/L) | lead<br>(mg/L) | total uranium <sup>a</sup><br>(ug/L) | zinc<br>(mg/L) | uranium-230<br>(mBq/L) | total radium<br>(mBq/L) | lead-210<br>(Bq/L) | polonium-210<br>(Bq/L) | uranium-235<br>(mBq/L) | protectinium-231<br>(mBq/L) |
|---------------------------------|-------------------|----------------|----------------|---------------------|------------------|----------------|--------------------------------------|----------------|------------------------|-------------------------|--------------------|------------------------|------------------------|-----------------------------|
| Spring L28N -Comp.              | <10               | <0.02          | 0.098          | <0.001              | <0.01            | <0.05          | 30/27                                | <0.002         | 1.27±0.05              | <5                      | 8±2                | -                      | -                      | -                           |
| Crack L28N -Comp.               | <10               | <0.02          | 0.32           | 0.006               | <0.01            | <0.05          | 60/58                                | 0.006          | 1.22±0.05              | <5                      | 11±3               | -                      | -                      | -                           |
| Crack L28N -Comp.<br>Station #1 | <10               | <0.02          | 0.044          | 0.004               | <0.01            | <0.05          | 48/45                                | <0.002         | 1.11±0.05              | <5                      | 11±3               | -                      | -                      | -                           |
| Crack L28N -22 Aug              | -                 | -              | -              | -                   | -                | -              | 54                                   | -              | -                      | <5                      | <5                 | -                      | -                      | -                           |
| Station #2 -27 Aug              | -                 | -              | -              | -                   | -                | -              | 38                                   | -              | -                      | <5                      | 17±4               | -                      | -                      | -                           |
| -Comp.                          | <10               | <0.02          | 0.014          | 0.003               | <0.01            | <0.05          | -                                    | <0.002         | 1.06±0.04              | -                       | -                  | 0.36±0.08              | 0.35±0.05              | 15±5                        |
| Bracy Brook                     |                   |                |                |                     |                  |                |                                      |                |                        |                         |                    |                        |                        |                             |
| East -Comp.                     | <10               | <0.02          | 0.11           | 0.006               | <0.01            | <0.05          | <0.5/±0.5                            | 0.012          | -                      | <5                      | <5                 | <0.3                   | 2.8±0.2                | <5                          |
| Bracy Brook                     |                   |                |                |                     |                  |                |                                      |                |                        |                         |                    |                        |                        |                             |
| West -Comp.                     | <10               | <0.02          | 0.14           | 0.005               | <0.01            | <0.05          | <0.5/±0.5                            | 0.009          | -                      | -                       | -                  | -                      | -                      | -                           |
| Bracy Brook                     |                   |                |                |                     |                  |                |                                      |                |                        |                         |                    |                        |                        |                             |
| Mouth -Comp.                    | <10               | <0.02          | 0.15           | 0.005               | <0.01            | <0.05          | <0.5/±0.5                            | <0.002         | -                      | <5                      | <5                 | -                      | -                      | -                           |
| Falls Lake                      |                   |                |                |                     |                  |                |                                      |                |                        |                         |                    |                        |                        |                             |
| Centre -Comp.                   | <10               | <0.02          | 0.15           | 0.003               | <0.01            | <0.05          | <0.5/1.0                             | 0.004          | -                      | -                       | -                  | -                      | -                      | -                           |
| Falls Lake -22 Aug              | -                 | -              | -              | -                   | -                | -              | <0.5                                 | -              | -                      | <5                      | <5                 | -                      | -                      | -                           |
| Outlet -27 Aug                  | -                 | -              | -              | -                   | -                | -              | 2.0                                  | -              | -                      | <5                      | 8±2                | -                      | -                      | -                           |
| -Comp.                          | <10               | <0.02          | 0.12           | 0.003               | <0.01            | <0.05          | -                                    | 0.011          | -                      | -                       | <0.3               | 5.4±0.5                | -                      | <5                          |
| Sullivan L.                     |                   |                |                |                     |                  |                |                                      |                |                        |                         |                    |                        |                        |                             |
| Outlet -Comp.                   | <10               | <0.02          | 0.22           | 0.009               | <0.01            | <0.05          | <0.5/±0.5                            | 0.016          | -                      | <5                      | <5                 | -                      | -                      | -                           |

## NOTE

a - where the two samples used to make a composite sample were first analyzed separately, both results are shown separated by a slash (/).

TABLE C-4

STREAM SEDIMENT CHEMISTRY  
MAJOR ELEMENTS AND RADIONUCLIDES

| Station         | uranium<br>( $\mu\text{g/g}$ ) | thorium<br>(ppm) | U ratio         | thorium-230<br>(Bq/g) | radium-226<br>(Bq/g) | lead-210<br>(Bq/g) | polonium-210<br>(Bq/g) | uranium-235<br>(Bq/g) | protactinium-231<br>(Bq/g) |
|-----------------|--------------------------------|------------------|-----------------|-----------------------|----------------------|--------------------|------------------------|-----------------------|----------------------------|
| Spring L28N     | 736                            | 3.3              | 1.35 $\pm$ 0.05 | 0.7 $\pm$ 0.049       | 0.647 $\pm$ 0.048    | 1.11 $\pm$ 0.09    | 3.6 $\pm$ 0.2 (6.5) *  | 0.24 $\pm$ 0.02       | <0.005                     |
| Creek L28N      | 3450                           | -                | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| Creek L24N      |                                |                  |                 |                       |                      |                    |                        |                       |                            |
| Station #1      | 6460                           | -                | 1.08 $\pm$ 0.05 | 4.21 $\pm$ 0.12       | 3.39 $\pm$ 0.10      | 5.50 $\pm$ 0.25    | 6.0 $\pm$ 0.4 (5.8)    | 2.1 $\pm$ 0.2         | <0.005                     |
| Special Station | 313                            | <1               | 0.84 $\pm$ 0.05 | -                     | -                    | -                  | -                      | -                     | -                          |
| Station #2      | 55.6                           | 5.7              | 2.2 $\pm$ 0.2   | 0.095 $\pm$ 0.019     | 0.193 $\pm$ 0.026    | -                  | -                      | -                     | -                          |
| Big Rock Pond   | 3140                           | -                | 1.11 $\pm$ 0.05 | 1.22 $\pm$ 0.073      | 1.61 $\pm$ 0.1       | -                  | -                      | -                     | -                          |
| Brady Brook     |                                |                  |                 |                       |                      |                    |                        |                       |                            |
| East            | 10.3                           | 8.1              | -               | 0.099 $\pm$ 0.019     | 0.088 $\pm$ 0.018    | -                  | -                      | -                     | -                          |
| East Special    | 11.2                           | -                | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| West            | 8.5                            | 8.0              | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| West Special    | 9.8                            | -                | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| Main Special    | 8.7                            | -                | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| Mouth           | 11.1                           | 10.2             | -               | 0.088 $\pm$ 0.016     | 0.06 $\pm$ 0.013     | -                  | -                      | -                     | -                          |
| Falls Lake      |                                |                  |                 |                       |                      |                    |                        |                       |                            |
| Damre           | 57.8                           | 4.6              | 1.6 $\pm$ 0.2   | 0.151 $\pm$ 0.026     | 0.157 $\pm$ 0.026    | -                  | -                      | -                     | -                          |
| Outlet          | 10.6                           | 3.0              | -               | 0.061 $\pm$ 0.015     | 0.075 $\pm$ 0.016    | -                  | -                      | -                     | -                          |
| Special #1      | 20.7                           | -                | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| Special #2      | 14.7                           | -                | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| Special #3      | 34.6                           | 9.6              | -               | 0.119 $\pm$ 0.021     | 0.064 $\pm$ 0.014    | -                  | -                      | -                     | -                          |
| Special #4      | 13.6                           | -                | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| Special #5      | 15.9                           | -                | -               | -                     | -                    | -                  | -                      | -                     | -                          |
| Suitcase L.     |                                |                  |                 |                       |                      |                    |                        |                       |                            |
| Outlet          | 6.4                            | 5.3              | -               | 0.106 $\pm$ 0.018     | 0.113 $\pm$ 0.018    | 0.33 $\pm$ 0.04    | 3.0 $\pm$ 0.2 (6.1)    | -                     | <0.005                     |

Note

\* - Time-adjusted polonium-210 values shown in parenthesis.

TABLE C-4 (cont'd)

| Station         | CaCO <sub>3</sub> equiv<br>(%) | total S<br>(ppm) | TKN<br>(ppm) | arsenic<br>(ppm) | copper<br>(ppm) | iron<br>(mg/g) | manganese<br>(ppm) | nickel<br>(ppm) | lead<br>(ppm) | zinc<br>(ppm) |
|-----------------|--------------------------------|------------------|--------------|------------------|-----------------|----------------|--------------------|-----------------|---------------|---------------|
| Spring L28N     | 1.1                            | <75              | 1420         | <1               | 6.8             | 19.2           | 259                | 13.9            | 43.3          | 8.8           |
| Creek L28N      | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Creek L24N      |                                |                  |              |                  |                 |                |                    |                 |               |               |
| Station #1      | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Special Station | 1.1                            | <75              | 770          | <1               | 2.6             | 9.1            | 185                | 31.5            | 16.9          | 2.1           |
| Station #2      | 0.2                            | <75              | 284          | <1               | 1.1             | 5.9            | 126                | 16.2            | 15.8          | 1.9           |
| Big Rock Pond   | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Brucy Brook     |                                |                  |              |                  |                 |                |                    |                 |               |               |
| East            | 1.3                            | <75              | 134          | <1               | 6.5             | 11.3           | 89                 | 12.4            | 16.8          | 2.5           |
| East Special    | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| West            | 1.9                            | <75              | 84           | <1               | 5.0             | 8.4            | 36                 | 21.4            | 19.5          | 2.5           |
| West Special    | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Main Special    | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Mouth           | 1.7                            | <75              | 234          | <1               | 3.4             | 10.4           | 154                | 34.9            | 15.8          | 2.1           |
| Falls Lake      |                                |                  |              |                  |                 |                |                    |                 |               |               |
| Centre          | 0.2                            | <75              | 990          | <1               | 2.6             | 10.1           | 170                | 14.7            | 15.4          | 2.9           |
| Outlet          | 2.4                            | <75              | 134          | <1               | 3.5             | 14.1           | 198                | 34.6            | 17.7          | 3.0           |
| Special #1      | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Special #2      | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Special #3      | 0.1                            | <75              | 1250         | <1               | 3.9             | 8.8            | 156                | 13.6            | 20.4          | 3.2           |
| Special #4      | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Special #5      | -                              | -                | -            | -                | -               | -              | -                  | -               | -             | -             |
| Suitcase L.     |                                |                  |              |                  |                 |                |                    |                 |               |               |
| Outlet          | 0.7                            | <75              | 50           | <1               | 3.9             | 8.0            | 107                | 12.9            | 14.5          | 2.8           |

APPENDIX D

BIOLOGY

TABLE D-1

## URANIUM IN VEGETATION

## MONENCO ANALYTICAL LABORATORIES

November 30, 1984

Rob Blair

Golder Associates

## Vegetation Samples - Portland Creek - Newfoundland

Samples Received: November 9, 1984

| Monenco # | Identification          | Uppm                            |
|-----------|-------------------------|---------------------------------|
| RV4774    | from<br>control<br>area | #1 } Balsam Fir Foliage ≤0.1    |
| RV4775    |                         | #2 } 1984 ≤0.1                  |
| RV4776    |                         | #3 } ≤0.1                       |
| RV4777    |                         | #4 } Balsam Fir Foliage ≤0.1    |
| RV4778    |                         | #5 } 1980 ≤0.1                  |
| RV4779    |                         | #6 } ≤0.1                       |
| RV4780    |                         | #7 } Black Spruce Foliage ≤0.1  |
| RV4781    |                         | #8 } 1984 ≤0.1                  |
| RV4782    |                         | #9 } ≤0.1                       |
| RV4783    |                         | #10 } White Birch Foliage ≤0.1  |
| RV4784    | from<br>deposit<br>area | #11 } 1984 ≤0.1                 |
| RV4785    |                         | #12 } ≤0.1                      |
| RV4786    |                         | #13 } ≤0.1                      |
| RV4787    |                         | #14 } Dryopteris ≤0.1           |
| RV4788    |                         | #15 } ≤0.1                      |
| RV4789    |                         | #16 } ≤0.1                      |
| RV4790    |                         | #17 } Hyloconium ≤0.1           |
| RV4791    |                         | #18 } ≤0.1                      |
| RV4792    |                         | #19 } ≤0.1                      |
| RV4793    |                         | #20 } Alecatoria ≤0.1           |
| RV4794    | from<br>deposit<br>area | #21 } ≤0.1                      |
| RV4795    |                         | #22 } ≤0.1                      |
| RV4796    |                         | #23 } Cornus Canadensis ≤0.1    |
| RV4797    |                         | #24 } ≤0.1                      |
| RV4798    |                         | #25 } Balsam Fir Foliage ≤0.1   |
| RV4799    |                         | #26 } 1984 ≤0.1                 |
| RV4800    |                         | #27 } ≤0.1                      |
| RV4801    |                         | #28 } Balsam Fir Foliage ≤0.1   |
| RV4802    |                         | #29 } 1980 ≤0.1                 |
| RV4803    |                         | #30 } ≤0.1                      |
| RV4804    | from<br>deposit<br>area | #31 } Black Spruce Foliage ≤0.1 |
| RV4805    |                         | #32 } 1984 0.4                  |
| RV4806    |                         | #33 } 0.2                       |
| RV4807    |                         | #34 } White Birch Foliage 1.6   |
| RV4808    |                         | #35 } 1984 0.5                  |
| RV4809    |                         | #36 } 0.4                       |
| RV4810    |                         | #37 } 1.5                       |
| RV4811    |                         | #38 } Dryopteris 1.5            |
| RV4812    |                         | #39 } 9.7                       |
| RV4813    |                         | #40 } 3.5                       |
| RV4814    | from<br>deposit<br>area | #41 } Hyloconium 3.7            |
| RV4815    |                         | #42 } 3.7                       |
| RV4816    |                         | #43 } Alecatoria 0.6            |
| RV4817    |                         | #44 } ≤0.1                      |



TABLE D-1 (cont'd)

URANIUM IN VEGETATION**MONENCO ANALYTICAL LABORATORIES**

November 30, 1984  
 Rob Blair  
 Golder Associates  
 (Page 2)

Vegetation Samples - Portland Creek - Newfoundland

Samples Received: November 9, 1984

| <u>Monenco #</u> | <u>Identification</u>                                                                           | <u>Uppm</u> |
|------------------|-------------------------------------------------------------------------------------------------|-------------|
| RV4818           | #45 Alectoria                                                                                   | 0.3         |
| RV4819           | #46 }<br>#47 }<br>#48 }<br>#49 }<br>#50 }<br>#51 }<br>#52 }<br>#53 }<br>#54 }<br>#55 }<br>#56 } | 1.6         |
| RV4820           | Cornus                                                                                          | 2.6         |
| RV4821           |                                                                                                 | 0.9         |
| RV4822           | deposit                                                                                         | 0.9         |
| RV4823           |                                                                                                 | 1.5         |
| RV4824           | control                                                                                         | ≤0.1        |
| RV4825           |                                                                                                 | 0.4         |
| RV4826           | deposit                                                                                         | ≤0.1        |
| RV4827           |                                                                                                 | ≤0.1        |
| RV4828           | control                                                                                         | ≤0.1        |
| RV4829           |                                                                                                 | ≤0.1        |

TABLE D-2

TAXONOMY  
AQUATIC INVERTEBRATES

# STREAM SAMPLE - INVERTEBRATES

TABLE D-2

LOCATION: Control Stream SAMPLE: 1A

| PHYLUM     | CLASS              | ORDER                                   | FAMILY                     | QUANTITY |
|------------|--------------------|-----------------------------------------|----------------------------|----------|
| Arthropoda | Hexapoda (Insects) | Diptera (Flies)                         | Chironomidae (midges)pupa* | 1        |
|            |                    | Unknown #1 - larvae*                    |                            |          |
|            |                    | { Hemiptera (bugs)                      |                            |          |
|            |                    | probably { Coleoptera (beetles)         |                            | 4        |
|            |                    | Ephemeroptera (mayflies)                | Leptophebiidae*            | 1        |
|            |                    |                                         | Heptageniidae larvae       | 1        |
|            |                    | Odonata (dragon flies and damsel flies) | Abdominal pieces*          | 2        |
|            |                    | Trichoptera (caddisflies)               | Hydropsychidae adult       | 1        |
|            |                    |                                         | Larval case - sand covered | 1        |
|            |                    | Unknown #2 - larvae*                    |                            | 1        |
|            |                    |                                         |                            | 12       |
|            |                    |                                         |                            | —        |

KEY \* indicates empty larva/pupa case  
( ) indicates common name

# STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

LOCATION: Control Stream SAMPLE: 2A

| PHYLUM                 | CLASS                    | ORDER                        | FAMILY                                                                | QUANTITY |
|------------------------|--------------------------|------------------------------|-----------------------------------------------------------------------|----------|
| Arthropoda             | Hexapoda (Insects)       | Diptera (Flies)              | Chironomidae (midges)                                                 | pupae    |
|                        |                          |                              |                                                                       | pupa*    |
|                        |                          |                              |                                                                       | 6        |
|                        |                          |                              |                                                                       | 1        |
|                        |                          |                              |                                                                       |          |
|                        |                          | Ephemeroptera (Mayflies)     | Ephemerellidae larva<br>Heptageniidae larva<br>Leptophlebiidae larvae | 1        |
|                        |                          |                              |                                                                       | 1        |
|                        |                          |                              |                                                                       | 2        |
|                        |                          |                              |                                                                       |          |
|                        |                          |                              |                                                                       |          |
|                        |                          | Trichoptera (Caddisflies)    | Hydropsychidae larvae<br>Philopotomidae larva                         | 9        |
|                        |                          |                              |                                                                       | 1        |
|                        |                          |                              |                                                                       |          |
|                        |                          |                              |                                                                       |          |
|                        |                          |                              |                                                                       |          |
| Subphylum<br>Crustacea | Malacostraca             | Amphipoda<br>sub order       | Gammaroidea                                                           | 1        |
|                        |                          |                              |                                                                       |          |
|                        |                          |                              |                                                                       |          |
|                        |                          |                              |                                                                       |          |
|                        |                          |                              |                                                                       |          |
| Platyhelminthes        | Turbellaria (planarians) | Trematoda (parasitic flukes) |                                                                       | 1        |
|                        |                          |                              |                                                                       | 1        |
|                        |                          |                              |                                                                       | 24       |
|                        |                          |                              |                                                                       |          |
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KEY  
\* indicates empty larva/pupa case  
( ) indicates common name

STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

LOCATION: Control Stream SAMPLE: 3A

| PHYLUM                | CLASS                  | ORDER                        | FAMILY                      | QUANTITY        |
|-----------------------|------------------------|------------------------------|-----------------------------|-----------------|
| Arthropoda            | Hexapoda (Insects)     | Diptera (flies)              | Chironomidae (midges)larvae | 85              |
|                       |                        |                              |                             |                 |
|                       |                        | Hymenoptera adult            |                             | 1               |
|                       |                        | Ephemeroptera (Mayflies)     | Heptageniidae larvae*       | 6               |
|                       |                        |                              |                             |                 |
|                       |                        | Trichoptera (Caddisflies)    | Hydropsychidae adult larvae | 1               |
|                       |                        |                              | Hydropsychidae larva        | 6               |
|                       |                        |                              | Leptoceridae larvae         | 1               |
|                       |                        |                              | Philopotomidae larvae       | 2               |
|                       |                        |                              | Philopotomidae larvae       | 10              |
| Rhyacophilidae larvae | 2                      |                              |                             |                 |
|                       |                        |                              |                             |                 |
|                       |                        | Plecoptera (Stoneflies)      | Capniidae larvae            | 4               |
|                       |                        | Unknown 4 - larvae           |                             | 1               |
|                       |                        | Acari (mites and ticks)      |                             | 3               |
|                       | Arachnida              |                              |                             |                 |
|                       |                        |                              |                             |                 |
|                       | Subphylum Crustacea    |                              |                             |                 |
|                       | Copepoda               |                              |                             |                 |
|                       |                        | Cyclopoida                   |                             | 2               |
|                       |                        |                              |                             |                 |
|                       | Platyhelminthes        |                              |                             |                 |
|                       |                        | Trematoda (parasitic flukes) |                             | 1               |
|                       |                        |                              |                             |                 |
|                       | Nematoda (round worms) |                              |                             | 5               |
|                       |                        |                              |                             |                 |
|                       |                        |                              |                             | <hr/> 130 <hr/> |
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# STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

LOCATION: Deposit Area SAMPLE: 1A

| PHYLUM                            | CLASS              | ORDER                        | FAMILY                      | QUANTITY |
|-----------------------------------|--------------------|------------------------------|-----------------------------|----------|
| Arthropoda                        | Hexapoda (Insects) | Ephemeroptera (Mayflies)     | Ephemere                    | 3        |
|                                   |                    |                              | rellidae larvae*            | 1        |
|                                   |                    |                              | Leptophlebiidae larva       |          |
|                                   |                    | Diptera (Flies)              | Chironomidae (midges) pupa* | 1        |
|                                   |                    | Trichoptera (Caddisflies)    |                             |          |
|                                   |                    |                              | Philopotamidae larva        | 1        |
| Subphylum<br>Crustacea            | Copepoda           |                              |                             |          |
|                                   |                    |                              |                             |          |
|                                   |                    | Cyclopoida                   |                             | 1        |
|                                   | Malacostraca       |                              |                             |          |
|                                   |                    | Amphipoda<br>sub order       | Gammaroidea                 | 3        |
| Platyhelminthes                   |                    | Trematoda (parasitic flukes) |                             | 1        |
| Mollusca                          |                    | Bivalvia (clam)              |                             | 2        |
| Annelida                          |                    | Hirudinea (leeches)          |                             | 1        |
| KEY                               |                    |                              |                             | 14       |
| * indicates empty larva/pupa case |                    |                              |                             |          |
| ( ) indicates common name         |                    |                              |                             |          |

TABLE D-2 (cont'd)

STREAM SAMPLE - INVERTEBRATES

LOCATION: Deposit Area      SAMPLE: 1B

| PHYLUM                 | CLASS                        | ORDER                      | FAMILY                       | QUANTITY  |
|------------------------|------------------------------|----------------------------|------------------------------|-----------|
| Arthropoda             | Hexapoda (Insects)           |                            |                              |           |
|                        |                              | Diptera (Flies)            | Chironomidae (midges) pupae* | 2         |
|                        |                              | Ephemeroptera (May Flies)  |                              |           |
|                        |                              |                            | Heptageniidae larva          | 1         |
|                        |                              |                            | Leptophlebiidae larvae*      | 2         |
|                        |                              | Trichoptera (Caddis Flies) | Philopotamidae larvae        | 5         |
| Subphylum<br>Crustacea | Copepoda                     | Cyclopoida                 |                              | 8         |
|                        | Arachnida                    | Acari (mites and ticks)    |                              | 1         |
| Platyhelminthes        | Trematoda (parasitic flukes) |                            |                              | 1         |
| Nematoda (round worms) |                              |                            |                              | 1         |
|                        |                              |                            |                              | <u>21</u> |

KEY  
 \* indicates empty larva/pupa case  
 ( ) indicates common name

# STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

LOCATION: Deposit Area SAMPLE: 2A

| PHYLUM                 | CLASS              | ORDER                     | FAMILY                                | QUANTITY |
|------------------------|--------------------|---------------------------|---------------------------------------|----------|
| Arthropoda             | Hexapoda (Insects) | Diptera (Flies)           | Chironomidae (midges) pupae*<br>larva | 2<br>1   |
|                        |                    |                           | Culicidae (mosquitoes)                | 1        |
|                        |                    | Ephemeroptera (May Flies) | Ephemerellidae larva<br>larvae*       | 1<br>2   |
|                        |                    |                           | Caenidae larva*                       | 1        |
|                        |                    |                           | Leptophlebiidae larvae*               | 2        |
|                        |                    | Unknown 1 - larva         |                                       | 1        |
| Subphylum<br>Crustacea | Branchiopoda       | Cladocera                 | (Daphnia like)                        | 2        |
|                        | Malacostraca       | Amphipoda                 |                                       |          |
|                        |                    | Sub order                 | Gammaroidea                           | 2        |
| Mollusca               | Bivalvia (clam)    |                           |                                       | 2        |
|                        |                    |                           |                                       | 17       |

KEY \* indicates empty larva/pupa case  
( ) indicates common name

# STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

Page 1 of 2 pages

LOCATION: Deposit Area SAMPLE: 2B

| PHYLUM     | CLASS              | ORDER                                                         | FAMILY                                         | QUANTITY |
|------------|--------------------|---------------------------------------------------------------|------------------------------------------------|----------|
| Arthropoda | Hexapoda (Insects) | Diptera (Flies)                                               |                                                |          |
|            |                    |                                                               | Simuliidae (black flies)<br>adult (poor shape) | 1        |
|            |                    |                                                               | Chironomidae (midges) larvae                   | 43       |
|            |                    |                                                               | Unknown 5 adult                                | 2        |
| KEY        |                    | Ephemeroptera (May flies)                                     |                                                |          |
|            |                    |                                                               | Ephemerellidae larva                           | 1        |
|            |                    |                                                               | Leptophlebiidae larvae<br>larvae*              | 27<br>10 |
|            |                    | Trichoptera (Caddis flies)                                    | Hydroptilidae larvae<br>Philopotamidae larva   | 3<br>1   |
|            |                    | Plecoptera (Stone flies)                                      | Capniidae larvae                               | 2        |
|            |                    | Coleoptera (Beetles)<br>(probably) Elateridae (click beetles) |                                                | 1        |
|            |                    | Unknown 1 - larvae                                            |                                                | 2        |
|            | Arachnida          | Acari (mites and ticks)                                       |                                                | 2        |

KEY  
\* indicates empty larva/pupa case  
( ) indicates common name

STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

Page 2 of 2 pages

LOCATION: Deposit Area SAMPLE: 2B

| PHYLUM | CLASS                  | ORDER     | FAMILY       | QUANTITY |
|--------|------------------------|-----------|--------------|----------|
| 13     | Subphylum<br>Crustacea | Copepoda  | Cyclopoida   | 1        |
|        |                        |           |              |          |
|        |                        |           |              |          |
|        |                        |           |              |          |
| 14     | Branchiopoda           | Cladocera | Daphnia like | 5        |
|        |                        |           |              |          |
| 15     | Malacostraca           | Amphipoda |              | 2        |
|        |                        |           |              |          |
| 16     | Nematoda (round worms) | Sub Order | Gammaroidea  | 2        |
|        |                        |           |              |          |
|        |                        |           |              | 105      |



# STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

LOCATION: Deposit Area SAMPLE: 3A

| PHYLUM              | CLASS              | ORDER                                     | FAMILY                           | QUANTITY |
|---------------------|--------------------|-------------------------------------------|----------------------------------|----------|
| Arthropoda          | Hexapoda (Insects) | Diptera (Flies)                           | Chironomidae (midges) larvae     | 6        |
|                     |                    |                                           | Ephemeroptera (May flies)        | 4        |
|                     |                    |                                           | Leptophlebiidae larvae           | 2        |
|                     |                    | Trichoptera (Caddis flies)                | Hydroptilidae larvae             | 1        |
|                     |                    | Plecoptera (Stone flies)                  | Capniidae                        | 2        |
|                     |                    | Unknown 6 probably                        | Collemboda (spring tails) larvae | 1        |
|                     | Arachnida          | Acari (mites and ticks)                   |                                  | 3        |
| Subphylum Crustacea | Malacostraca       | Amphipoda<br><u>Sub Order</u> Gammaroidea |                                  | 3        |
| Platyhelminthes     |                    |                                           |                                  |          |
|                     |                    | Trematoda (parasitic flukes)              |                                  | 1        |
|                     |                    |                                           |                                  | 23       |

KEY

\* indicates empty larva/pupa case

( ) indicates common name

KEY \* indicates empty larva/pupa case  
( ) indicates common name

# STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

LOCATION: Deposit Area SAMPLE: 3B

| PHYLUM                 | CLASS                        | ORDER                              | FAMILY                       | QUANTITY |
|------------------------|------------------------------|------------------------------------|------------------------------|----------|
| Arthropoda             | Hexapoda (Insects)           | Diptera (Flies)                    | Chironomidae (midges) larvae | 12       |
|                        |                              |                                    | Culicidae (mosquitoes) adult | 1        |
|                        |                              |                                    | Simuliidae (black flies)     | 1        |
|                        |                              | Ephemeroptera (May flies)          | Ephemerellidae larvae        | 2        |
|                        |                              |                                    | Caenidae larva               | 1        |
|                        |                              |                                    | Leptophlebiidae larvae       | 5        |
|                        |                              | Plecoptera (Stone flies)           | Capniidae larvae*            | 3        |
|                        |                              | Unknown 1 - larvae*                |                              | 4        |
| Subphylum<br>Crustacea | Branchiopoda                 | Cladocera                          | Daphnia like                 | 1        |
|                        | Copepoda                     | Calanoida                          |                              | 1        |
|                        | Malacostraca                 | Amphipoda<br>Sub Order Gammaroidea |                              | 4        |
| Platyhelminthes        | Trematoda (parasitic flukes) |                                    |                              | 1        |
| Mollusca               | Bivalva (clam) shell         |                                    |                              | 1        |
|                        |                              |                                    |                              | 37       |

## KEY

\* indicates empty larva/pupa case  
( ) indicates common name

# STREAM SAMPLE - INVERTEBRATES

TABLE D-2 (cont'd)

Page 1 of 2 pag

LOCATION: Deposit Area SAMPLE: 3C

| PHYLUM                 | CLASS              | ORDER                   | FAMILY                             | QUANTITY |
|------------------------|--------------------|-------------------------|------------------------------------|----------|
| Arthropoda             | Hexapoda (Insects) | Diptera (Flies)         | Chironomidae (midges)larvae        | 73       |
|                        |                    |                         | pupae                              | 3        |
|                        |                    |                         | Culicidae (mosquitoes)adult        | 1        |
|                        |                    |                         | Simuliidae (black flies)adult      | 1        |
|                        |                    |                         | Ephemeroptera (May flies)          | 13       |
|                        |                    |                         | Heptageniidae larvae*              | 7        |
|                        |                    |                         | Leptophlebiidae larvae             |          |
|                        |                    |                         | Trichoptera (Caddis flies)         | 15       |
|                        |                    |                         | Hydroptilidae larvae               |          |
|                        |                    |                         | Plecoptera (Stone flies)           | 1        |
|                        |                    |                         | Capniidae                          |          |
|                        |                    |                         | Unknown 1 - larvae (4 empty cases) | 8        |
|                        |                    |                         | Unknown 7 - larvae                 |          |
|                        |                    |                         | - similar to Diptera               |          |
| Subphylum<br>Crustacea | Arachnida          | Acari (mites and ticks) | Cyclorhapha larvae                 | 1        |
|                        |                    |                         | type A                             | 9        |
|                        |                    |                         | type B                             | 1        |
|                        |                    |                         |                                    |          |
|                        |                    |                         |                                    |          |
|                        | Copepoda           | Calanoida               |                                    | 3        |
|                        |                    |                         |                                    |          |
|                        |                    |                         |                                    |          |
|                        |                    |                         |                                    |          |
|                        |                    |                         | Cyclopoida                         | 1        |

STREAM SAMPL - INVERTEBRATES

TABLE D-2 (cont'd)

Page 2 of 2 pages

LOCATION: Deposit Area SAMPLE: 3C

|    | PHYLUM                 | CLASS                       | ORDER                 | FAMILY | QUANTITY |
|----|------------------------|-----------------------------|-----------------------|--------|----------|
| 15 | Arthropoda             |                             |                       |        |          |
|    | Subphylum              |                             |                       |        |          |
|    | Crustacea              |                             |                       |        |          |
|    |                        | Malacostraca                |                       |        |          |
|    |                        |                             | Amphipoda             |        | 3        |
|    |                        |                             | Sub Order Gammaroidea |        | 1        |
| 16 | Nematoda (round worms) |                             |                       |        |          |
|    | Mollusca               |                             |                       |        |          |
|    |                        | Bivalva (clam) empty shells |                       |        | 3        |
|    |                        |                             |                       |        | 144      |
|    |                        |                             |                       |        |          |
| 17 | Invertebrate eggs      |                             |                       |        |          |
|    |                        |                             |                       | type a | many     |
|    |                        |                             |                       | type b | many     |

KEY

\* indicates empty larva/pupa case  
( ) indicates common name

TABLE D-3

## MONTANA ANALYTICAL LABORATORIES

22-2023 and Avenue S.E.

Calgary, Alberta T2E 6K1

Bruce Robert

January 29, 1985

February 1, 1985

## URANIUM CONCENTRATIONS AND RADIOISOTOPE ACTIVITIES

## VEGETATION AND FISH

| Reference No.        | Identification                       | U ppm | -----Bq/g----- |             |             |             | -----Bq/g----- |           |             |                 |
|----------------------|--------------------------------------|-------|----------------|-------------|-------------|-------------|----------------|-----------|-------------|-----------------|
|                      |                                      |       | Ra-226         | Th-230      | U-234/U-238 | U-235       | Po-210         | Pb-210    | Po-210      | As of Jan 21/85 |
| Foliage              | RV783 W. Birch #10 Control Area      | ±0.1  | 0.011±0.002    | ±0.005      |             |             |                |           |             |                 |
|                      | RV783 Alektor #20 Control Area       | ±0.1  | ±0.005         | ±0.005      |             |             |                |           |             |                 |
|                      | RV826 1980 B. Fir #0 Deposit Area    | ±0.1  | 0.290±0.014    | 0.009±0.002 |             |             |                |           |             |                 |
|                      | RV826 1980 B. Fir #0 Deposit Area #7 | ±0.1  | 1.44 ±0.04     | 0.009±0.002 | 2.20±0.05   | 0.005±0.001 | ±0.005         | 0.50±0.05 | 0.008±0.008 |                 |
|                      | RV826 1980 B. Fir #0 Deposit Area #7 | ±0.1  | 0.226±0.011    | 0.006±0.002 | 2.35±0.12   | 0.002±0.001 | ±0.005         | 1.11±0.10 | 0.52 ±0.03  |                 |
| Bark, Wood and Roots | RV5002 Balsam poplar #17 Control     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #18 Control     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #19 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #20 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #21 Control     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #22 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #23 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #24 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #25 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #26 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #27 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #28 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #29 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #30 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #31 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #32 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #33 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #34 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #35 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #36 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #37 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #38 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #39 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #40 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #41 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #42 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #43 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #44 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #45 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #46 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #47 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #48 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #49 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #50 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #51 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #52 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #53 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #54 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #55 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #56 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #57 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #58 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #59 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #60 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #61 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #62 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #63 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #64 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #65 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #66 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #67 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #68 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #69 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #70 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #71 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #72 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #73 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #74 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #75 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #76 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #77 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #78 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #79 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #80 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #81 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #82 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #83 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #84 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #85 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #86 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #87 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #88 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #89 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #90 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #91 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #92 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #93 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #94 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #95 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #96 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #97 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #98 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #99 Deposit     | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #100 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #101 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #102 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #103 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #104 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #105 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #106 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #107 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #108 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #109 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #110 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #111 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #112 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #113 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #114 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #115 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #116 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #117 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #118 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #119 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #120 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #121 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #122 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #123 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #124 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #125 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #126 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #127 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #128 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #129 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #130 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #131 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #132 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #133 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #134 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #135 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #136 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #137 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #138 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #139 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #140 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #141 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #142 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #143 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #144 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #145 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #146 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #147 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #148 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #149 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #150 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #151 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #152 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #153 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #154 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #155 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #156 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #157 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #158 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #159 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #160 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #161 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #162 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #163 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #164 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #165 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #166 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #167 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #168 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #169 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #170 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #171 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #172 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #173 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #174 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #175 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #176 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #177 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #178 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #179 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #180 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #181 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #182 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #183 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #184 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #185 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #186 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #187 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #188 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #189 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #190 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #191 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
| Fish                 | RV5002 Balsam poplar #192 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #193 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #194 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |
|                      | RV5002 Balsam poplar #195 Deposit    | ±0.1  |                |             |             |             |                |           |             |                 |